Children’s Cognitive Representations of the Local Environment

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I, James Paskins, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

This thesis examines the relationship between children's travel behaviour and their cognitive representations of the local environment. The aim is to examine the effects of children's experience of travel behaviour in the local environment on the formation of their cognitive maps, particularly the effects of experience gained independently of adult supervision.

There is a large degree of interplay between the factors within this relationship. Successful wayfinding is a prerequisite for independent travel, for example for walking to a friend's house or visiting the local park without an adult. Children's wayfinding relies on cognitive representations of the local environment which are used to plan routes and monitor their progress along them. Independent mobility allows children to build up cognitive representations of the local environment, and practice the skills that they require to travel alone further afield.

The basic hypothesis under examination is that independent travel and activities result in better cognitive representations of the local environment. One reason for this is that there are differences between the experiences of children who are passengers in cars and buses, and those who are involved in active travel. As passengers, children do not need to focus on the detail of the journey, particularly during car journeys. The roles of travel mode and whether the child was accompanied by an adult are examined.

The research in this thesis uses GPS data, questionnaires and sketch maps to examine children's behaviour and their environmental knowledge. Sketch maps have been analysed for style, detail and accuracy. The measurement of accuracy, obtained using bidimensional regression, has been combined with a measure of detail to provide an overall map score. Analysis of variance revealed significant gains in map scores as children become older and if they spend more of their travel time walking than in the car.

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1 Introduction

The topic for this thesis is the relationship between children's travel behaviour and the cognitive representations that they construct to store information about their local environments.

The purpose of this chapter is to contextualise and to justify the research. The research will be placed in the context of psychology, geography and transport research. In addition, the introduction will describe how the work is structured. The first step, however, is to place the research within a cultural context, and explain the reasons why children's travel, and their resulting spatial representations are a suitable subject for research.

1.1 Aims and objectives

The main aim of the research is to investigate the possibility that a link exists between children's interaction with the local environment and their cognitive representations of the environment. The thesis will explore the role of travel in children's lives and the ways in which mode choice can have lasting consequences.

The thesis will argue that children are becoming increasingly dependent on the car and that this is replacing active travel modes, in particular walking. It will be further argued that this shift in travel patterns has led to both physical and psychological consequences for some children.

This investigation required the development of research instruments that could build a picture of children's lives, their behaviours and travel patterns, and others that could investigate the quality of their mental representations of the local environment. During the course of the research for this thesis GPS data, questionnaires, diaries, sketch maps and other measures of spatial knowledge and reasoning were employed.

An objective of the research programme was to analyse the data recorded in the children's questionnaires and diaries to derive indicators for children's travel and independent behaviour.

Another objective was to develop a methodology for recording and analysing children's representations of the local environment. The research focused on children's sketch maps and investigated different methods of analysis; including style, detail and accuracy. The measurement of accuracy, obtained using bidimensional regression, has been combined with a measure of detail to provide an overall map score.

The main aim of the research will be addressed by investigating how the measures of children's behaviour, derived from the questionnaire and diary studies, influence children's representations of the local environment.

1.2 Structure

1.2.1 Chapters

This thesis is divided into 11 chapters:

Chapter 2 discusses children's travel behaviour, in particular the journey to school. Children's travel patterns are changing and this change has health and environmental impacts, and may be leading to a generation of car dependent children.

In **Chapter 3** the concept of the cognitive map and its application for children's environmental knowledge will be explored. The cognitive map is seen as a vital underpinning for wayfinding, and thereby independent behaviour.

Chapter 4 gives details about the main data collection for the research, including a discussion of the differences between the two primary schools that the children in the study attended. The schedule for data collection using the travel and activity diaries and GPS monitors is also covered.

Chapter 5 explains the choice of sketch mapping as the main measure of children's spatial knowledge. The pros and cons of this method, compared with instruments that made use of pre-selected landmarks are discussed. This chapter also discusses the potential for GPS tracking to be used as an instrument to provide details about the children's journeys.

Chapter 6 goes into some detail about the process of extracting objective measures of detail and accuracy from the children's highly individual maps. The length of the chapter reflects the time taken to process the sketch maps

Chapter 7 describes an exploratory factor analysis that was used to extract factors about children's independent behaviour from the CAPABLE child questionnaire. Regression analysis is then used to investigate the influence of the factors derived from the questionnaire on the accuracy of the children's sketch maps.

Chapter 8 examines distance representation and the overall style of representation used in the maps. Comparing the distances represented in sketch maps and the real world distances reveals systematic distortions in the sketch maps. The style of map representation shows differences between children at the two schools and differences related to travel mode.

Chapter 9 describes how sketch maps can be analysed for cartographic competence on the basis of the style employed to represent the landmarks.

Chapter 10 uses a sketch map detail and accuracy to further investigate the possibility that travel mode affects cognitive map quality.

Chapter 11 concludes this thesis with a summary of the research findings and thoughts for future investigations.

1.2.2 Appendices

In addition to the main text there are 10 appendices:

Appendix 1 includes the letters used during the fieldwork: an initial letter seeking schools to participate in the fieldwork and a letter asking for parental consent for their children to be involved in the fieldwork.

Appendix 2 gives example pages from the travel and activity diary used in the fieldwork.

Appendix 3 discusses the choices made about electronic monitors that measured the children's physical activity and their location, and gives details of the units employed for the fieldwork.

Appendices 4–6 show the materials used with the classroom groups to elicit children's sketch maps of the route to school and the area around the school.

Appendices 7-9 shows all of the sketch maps gathered during the fieldwork at the two schools in Cheshunt.

Appendix 10 shows the two-page questionnaire designed to gather information about children's travel and other activities that was given to pupils as part of the research.

1.3 Data collection

The thesis is based on data collected during CAPABLE (Children's Activities, Perceptions and Behaviour in the Local Environment) an EPSRC funded research project that the author worked on as a Research Fellow between 2004 and 2006. The CAPABLE project studied the travel and activity patterns of children in years 4, 5 and 6 of primary school (aged between 8 and 11 years old). Electronic monitors for physical activity (accelerometers) and location (GPS) were combined with classroom based exercises (questionnaires and sketch mapping exercises) to gather information about travel and play patterns. This thesis considers a sub-sample of 278 children who attended two schools in Cheshunt, a town in Hertfordshire.

1.3.1 Fieldwork in schools

The journey to primary school is a journey that is shared by a large number of children. During term time a large proportion of the 3,331,000 5-10 year old children who make up the state school population (Department for Education, 2011) will be making journeys to school. Although children will make journeys to a school from a variety of locations, they will experience the same local environment, roughly centred on the school. It is recognised that in many cases there will be little, or no, overlap between the environmental experiences of two children, however, overall there will be a large degree of common experience as children travel to a common location.

The journey to school is interesting to study because of the fact that it has been cited in arguments about congestion, global warming and children's health. In addition the school also offers a convenient place for the researcher to recruit a sample of participants and then to administer questionnaires and other instruments.

1.4 Methods used in the research

1.4.1 Measures for children's behaviour

As the purpose of this study was to investigate the possibility of a link between children's travel and activity, and their cognitive representations of the local environment, it was necessary to build a picture of children's travel and activities.

The two instruments that were used to do this were a questionnaire (see Chapter 7 and Appendix 10) and a diary study (see Chapter 9 and Appendix 2). The children's questionnaire asked questions about the ways in which children travelled and what kinds of activities they took part in. The diary study aimed to produce a record of all the journeys, destinations and activities for a child over a four-day period (two days during the week and the two weekend days).

A third method, GPS monitoring, was trialled, but was not used in the final analysis. Details of the GPS monitoring work are included in Chapter 5.

The GPS, questionnaire and diary studies were developed for the CAPABLE study, with contributions from the author. The fieldwork for this thesis was designed to make use of the data that was being collected as part of an existing study.

1.4.2 Outcome measures for the study

The outcome measures for this research consisted of measures derived from analysis of the children’s sketch maps (see Chapters 8–10). The sketch mapping protocol was developed by the author exclusively for the research for this thesis.

Questionnaire data was collected using the CAPABLE Child Questionnaire version 16 (see Appendix 10).

1.5 Note on the sketch maps

The thesis relies heavily on interpreting the contents of route and area maps that have been sketched by children. It was necessary to make judgements both about the representational style used by the children for their maps, and also which parts of the children’s drawing, referred to as “sketch map elements” represent specific, identifiable, landmarks. The sketch map elements were used to carry out more objective numerical assessments of sketch map accuracy that made use of the configurations of landmarks recorded in the sketch maps. A number of scanned images of the children’s maps are included as examples in the main text. There is not, however, enough space to include the maps drawn by all 278 children at full size. However, all the maps are included, at a reduced size, in a series of appendices at the end of the thesis (Appendices 7 – 9). Each child’s sketch maps appear in one of the appendices, based on whether the style of their area map was assessed as ‘pictorial’, ‘plan-pictorial’ or ‘plan’, the meanings of each of these categories is covered in greater depth in Chapter 8.

2 Children's travel

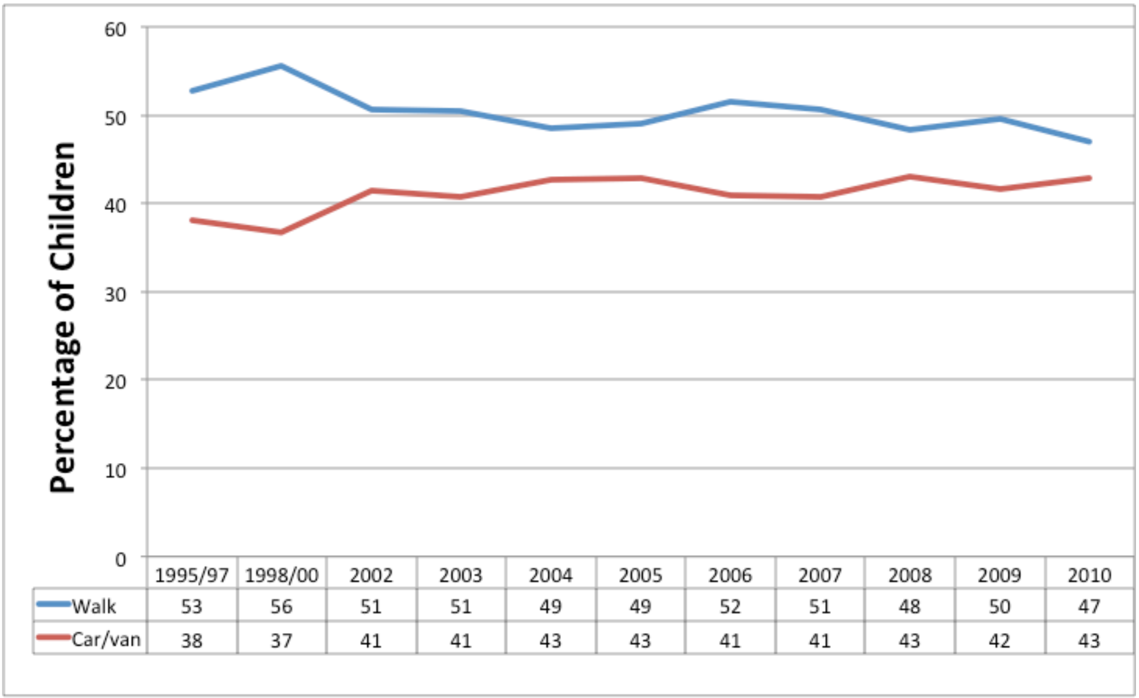
2.1 Concern about children's travel patterns

Children's travel, and in particular the choices made about how children travel to school, has come under scrutiny from researchers, policy makers and the media. The main focus for concern is the perception that children are using the car for an increasing amount of their day-to-day travel, and that this may have negative consequences in the long term. Over recent decades travel by car has become more prevalent for children in the developed world. The trend for increasing car use for children's travel has been investigated by researchers, including those in the UK (Hillman, 2006; Tudor-Locke, Ainsworth, & Popkin, 2001; van Sluijs et al., 2009), the USA (McDonald, 2007) and Australia (van der Ploeg, Merom, Corpuz, & Adrian, 2008; Yeung, Wearing, & Hills, 2008).

Previous UK Government policy has specifically addressed the concern that there are long-term impacts arising from the day-to-day choices made about children's mode of travel, including possible impacts on children's long-term health. One of the ways that these long term impacts on children's travel have been characterised is through the concept of car dependency (Fyhri & Hjorthol, 2009; Mackett, 2002), which captures the concern that the ways that children travel when they are young will influence their future travel patterns. It can be argued that if today's children are being trained to use the car for their travel, and are not exploring the alternatives, they will be will be ill equipped to travel by other modes. Walking, for instance, relies on the skill of wayfinding, the ability to plan a route between two locations and follow it (Loomis, Klatzky, Golledge, & Philbeck, 1999). If this is the case then there may be long-term negative consequences for both the individual and the wider environment.

2.2 Mode for the journey to school

One particular area that has been the focus of concern about children's travel is the journey to school. The increase in the number of children who travel by car, and the possible impacts of this change, has been the subject of research in the field of transport studies (Mackett, 2002; Mackett, Lucas, Paskins, & Turbin, 2002), geography (Barker, 2006) and health (Faulkner, Buliung, Flora, & Fusco, 2009).



	1995/97	1998/00	2002	2003	2004	2005	2006	2007	2008	2009	2010
Walk	53	56	51	51	49	49	52	51	48	50	47
Car/van	38	37	41	41	43	43	41	41	43	42	43

Figure 2-1: Percentage of 5–10 year old children walking and using the car for trips to and from school (Department for Transport, 2011a)

Recent figures from the National Travel Survey (Department for Transport, 2011a) show that, the proportion of children travelling by car is following a general upward trend, increasing with little sign of returning to the levels seen in earlier decades (see Figure 2–1).

During school term times the journey to school is part of children's rhythm of everyday travel behaviour. Children's travel to school by car is something that has an observable impact. For instance, figures from the Department for Transport show that in 2009, during term time, 21% of cars in peak traffic were taking children to school; this was an increase from 14% in 1995/97 (Department for Transport, 2009). It should not be assumed that these trips only exist because of the need to take children to school. Previous work has shown the importance of trip chaining to cope with complicated schedules (Hensher & Reyes, 2000). If a journey combines a father's journey to work and a son's journey to school, then removing the school trip element will not remove the car from the road entirely.

2.3 Children and sustainable travel

The role of school travel has been identified as a significant factor in sustainable travel, including the previously noted concern that car travel for school trips is building in car dependency at an early age (Department of the Environment Transport and the Regions, 1997). In the Department for Transport's 2011 White Paper 'Creating Growth, Cutting Carbon' (Department for Transport, 2011b) active travel for journeys to school, children walking or cycling instead of being carried as passengers in a car, was presented as an alternative to vehicle trips. It was suggested that this could not only reduce local congestion and carbon emissions, but could also improve children's achievement in school and their cognitive performance.

Much of the debate around the consequences for the individual relate to the impact of passive modes on the children's physical health. However, there are concerns about the wider environment as well, among them are concerns over the impacts that powered transport has for environmental sustainability. For example, passenger cars were responsible for over half (55.2%) of the GHG (greenhouse gas emissions) from the transport sector in 2008, which equates to over 72 Mt of CO_2 equivalent for the year (Department for Transport, 2010).

2.4 Health benefits of active travel

One way to consider the impacts on children's health from passive modes is by looking at the opposite, the benefits that arise from active travel. There is evidence for a wide range of benefits from active transport; it has been linked to a reduction in the risk of a wide range of health related conditions, including coronary heart disease, diabetes, obesity and many forms of cancer (Department of Health, 2004). Some researchers have gone further and put a value on the benefits (mostly arising from short-term and long-term health gains) associated with active travel (Department for Transport, 2011b). These estimates suggest that there is a £600 return annually for each pupil making the shift from travelling by car to walking and cycling. There is also recognition that physical activity can have positive impacts on mental wellbeing (Department of Health, 2004).

One of the mechanisms that might account for the health gains is the increased amount of physical activity expended using active modes, compared to travelling as a passenger. Physical activity has been found to be important for current and future physical and mental health (Biddle et al. 2004; Donaldson 2003). It has been shown that children who travel to school by active means, which in the UK is mainly walking, expend significantly more energy than those who travel by motorised transport (Faulkner et al., 2009; Mackett, Lucas, Paskins, & Turbin, 2005).

The benefits for physical activity that accrue from walking to school are not limited to the journey itself, children who use active travel modes for the journey to school have higher overall physical activity levels. The benefits for overall physical activity for children who use active modes has been shown in results from the CAPABLE study (Mackett & Paskins, 2008) and ALSPAC (The Avon Longitudinal Study of Parents and Children) (van Sluijs et al., 2009).

The important role played by physical activity in children's long term development, and the protection it offers from morbidity and mortality, are recognised in guidelines for the amount of physical activity that children should take part in. Guidelines issued in the UK (Department of Health, 2004) state that "Children and young people should achieve a total of at least 60 minutes of at least moderate intensity physical activity each day. At least twice a week this should include activities to improve bone health (activities that produce high physical stress on the bones), muscle strength and flexibility." (p.3). The suggestions for moderate intensity activities that children can take part in include brisk walking and cycling, both of which could be part of a children's journeys, also suggested are swimming, most sports and dancing. It seems clear that a large number of these moderate physical activities can be part of the children's everyday lives.

If we consider the mechanism of car dependency, then it is likely that those children who already travel by modes that require the minimum exertion will continue to do so, and join the general trend of decreasing physical activity that has affected all sections of the population in Great Britain, including children (Fox, 2004).

2.5 Obesity and travel mode

Concerns about levels of physical activity are often linked to concerns about the prevalence of obesity, and has been discussed in terms of an obesity 'epidemic' (House of Commons Health Committee, 2004). Although it is a term that is usually reserved for rapidly spreading contagious diseases, the report's writers felt they were justified in describing the 400% increase in overweight and obesity, seen in the 25 years before the reports publication in 2004, as an epidemic. It should be recognised that obesity is a highly contested term, and that some have argued that hyperbolic language can be stigmatising (Evans, 2006). Evans cites not only 'epidemic', but also the terms 'gluttony' and 'sloth', also used in the Select Committee report and elsewhere, as examples of stigmatising language.

Whether or not we accept the description of obesity as an epidemic, there has been a notable increase in childhood overweight and obesity, leading to concerns about short-term impacts, and the longer-term impacts from the body composition of today’s children. There is evidence that obese and overweight children are predisposed to developing serious metabolic disorders, such as diabetes, something that has been described as a “health time-bomb” (Donaldson, 2003).

A BMJ editorial from 2001 highlights the 60% increase in the numbers of 3 and 4 year old children who could be classified as overweight, and the increase of 70% in the same age group who could be classified as obese (Dietz, 2001). There has been a measurable rise in the percentage of overweight and obese children in Great Britain: the percentage of obese children aged 2–10 increased from 9.9% in 1995 to 13.7% in 2003. Over the same period, the percentage who were overweight rose from 22.7% to 27.7% (Jotangia, Moody, Stamatakis, & Wardle, 2006). This level of overweight and obesity presents real concerns for future health of these children.

Children who have obese parents are at an increased risk of becoming obese (Reilly, 2005). Whitaker & Dietz (1998) have shown that children who are overweight after the age of 3 have an increased risk of obesity, whatever weight their parents are. Epidemiological studies suggest that there will be further increases in the prevalence of adult obesity (Bundred, 2001). This pattern, particularly the influence of obese parents seems to suggest a cycle of obesity.

It is not surprising that concerns about children’s physical activity are often tied to concerns about obesity and their current and future health. Encouraging children into active travel has been suggested as a way to increase day-to-day physical activity (Pont, Ziviani, Wadley, & Bennett, 2009).

2.5.1 Obesogenic environments and children’s activity patterns

It has been suggested that today’s built environment is obesogenic, that is the design of infrastructure and services has some responsibility for the level of obesity in society (Swinburn & Egger, 1999). The reliance on motorised transport, and the style of planning it makes possible, have been identified majors factor in the obesogenic environments (Hinde & Dixon, 2005).

The environmental factors that can determine active travel by children and adults have been subject of much research. For adults having a higher population density, connectivity in the street network, diverse land use, and adequate provision of infrastructure for pedestrians and cyclist have been found to be linked to active travel (Sallis & Frank, 2004). These groups of factors are sometimes characterised as 3 (or more) D's, density, diversity and design (Cervero & Kockelman, 1997), or destination, distance and density (Lee & Moudon, 2006), and can be seen as indicators of the walkability of an area. For children factors such as greater distance, higher household income and owning more cars have also been associated with a reduction in numbers who choose to travel by active means (Pont et al., 2009).

When a close study is made of where children take part in their physical activity it is found that one of the most important factors for high intensity physical activity is the time spent out of the child's own home (Mackett et al., 2005). The results of the CAPABLE programme, which will be discussed in more detail later in this thesis, reveal that children's activities at home are, overall, the least energy intensive things that a child will do in a day. The most intense physical activity takes place out of the home in unstructured activities, which are activities where the children decide what to do; unstructured activities are essentially playing out of the home.

2.6 Children's decreasing mobility

The mode that children use to travel is one aspect of the way that children travel; another is who accompanies them and the level of independent mobility they are allowed. The decrease in children's independent mobility is another issue that has prompted attention from the media, policy makers and academics. Children's loss of independent mobility is linked to their increasing car dependence (Hillman, Adams, & Whitelegg, 1990; Mackett, 2002; Pooley, Turnbull, & Adams, 2005).

For adults with driving licences and a car, being car dependent does not translate into a reduction in independent mobility: far from it, cars have increased people's geographical range, which makes many more locations and activities accessible. For children, however, being car dependent can translate into a reduction in independent mobility; their car journeys are made as passive passengers, and because of this, they are not only car dependent, they are also dependent on a car driver.

2.6.1 Living in a car culture

The wide availability of private cars has made affordable motorised transport available to a large part of the UK population. A number of writers have linked the kind of mobility made possible by motorised transport with radical changes in western society (Jacobs, 1989; Kopnina, 2011). John C. Burnham is credited with introducing the term "automobility" (Flink, 1976) which refers to the ways that the freedom granted by car travel has played an important role in shaping the modern world.

In his book "The Car Culture" James Flink uses the term to refer to the increased reliance on cars for day-to-day activities, and argues that this dependence has had wide ranging ramifications for American culture. The changes brought about by reliance on the car, and other motorised transport, have been identified as elements of obesogenic environments (Hinde & Dixon, 2005).

2.6.2 Loss of freedom on the journey to school

If we take the example of the journey to school, we can see that this is an activity where children have experienced a loss of freedom. In Great Britain, in recent years children have been much less likely to travel to school by walking, or on a bicycle, and much more likely to make the journey by travelling in a car. Thus removing even the possibility that they might travel independently. In 2009, 84% of children aged 7-10 were usually accompanied on the journey to school, an increase from 78% in 2002 (Department for Transport, 2009). Children's independence when travelling, particularly when travelling to school, is at a very low level.

Pooley et al. (2005) used interviews to study the travel behaviour of 10–11 year olds, they found that travelling alone to school was much more common for those born in 1932-41 (~40%) than for those born in 1990-91 (9%). They suggest that the change is due to the increased availability of cars, more parental choice over schools, an increasing pace of life, and concerns over children's safety.

2.6.3 Children's geographies

"Children see things in environments that we may have forgotten how to see, let alone understand". (Aitken and Herman, 1997, p. 64).

Aitken and Herman (1997) make the point that by the time we reach adulthood, and are able to reflect on being a young child, we are very far removed from that experience. This makes it unlikely that adults will be capable of fully imagining the mental life of a child. The suggestion that adults cannot cognitively process the experiences of early childhood has been described as 'childhood amnesia' (Schachtel, 1959). Because of this Matthews (1992) asks if it is possible for adults to ever gain more than a 'meager glimpse' of children's environmental experience. Some have argued that the research about children's geographies often reveals more about the researchers, than it does about the children (Aitken & Herman, 1997). To avoid these biases, children's geographers have developed novel methods for investigating children's experience of the environment, often in consultation with the subjects of their research (Aitken, 2001).

There are a number of questions that can be asked about children's relationship with, and representations of, the local environment. There are also a number of different ways of asking those questions, and framing the investigation. Children's geographers have, in many cases concentrated on the socially constructed nature of childhood (Gregory, Johnston, Pratt, Watts & Whatmore, 2011). There has for instance been a focus on identity formation and rights, and a concentration on the role of children as social actors, rather than as objects of learning (Gregory et al., 2011).

Horton and Kraftl (2006) point out the importance of including the study of the everyday in the field of children's geographies. Their definition of 'everydayness' includes, the often repeated activities that might be considered as too mundane to record. The authors also point out how much can be taken from any space, and make the point that children's spaces are made up not just of the 'large scale navigable' features (the main focus of this research) but also the minute, and the highly personal, what Massey (1998) described as an unutterable complexity.

This research will take the study of an 'everyday' activity for children, but the investigation will proceed through a study of children's behaviour and learning, rather than a study based on identity formation.

2.7 Psychological benefits of active travel

While the benefits of physical activity from walking and cycling have are well studied, there has been less work on the psychological impacts that arise from the ways in which children travel, although it has been suggested that restrictions imposed on children by traffic can limit their development (Ward, 1978).

What can be considered as psychological impacts cover a wide range of phenomena, it has been shown that environment and physical exercise can affect mood in children. For instance, fifteen minutes of aerobic exercise has been shown to cause a significant increase in positive mood amongst 9 to 10 year old children (Williamson & Dewey, 2001). It has been suggested that the kind of physical activity associated with active travelling, and children's play, is sufficient to ameliorate negative psychological states including anxiety (Merom et al., 2008).Whereas the psychological impacts of reduced physical activity can include an increase in anxiety and an increased incidence of depression (Biddle, Gorely, & Stensel, 2004).

These negative psychological states are not the focus of the thesis, instead the research will deal with aspects of children's normal cognitive functioning, dealing particularly with the learning of spatial relationships in reaction to experience of the environment. The concepts of the cognitive map and the process of wayfinding will be dealt with in more detail in the next chapter.

2.8 Chapter summary

This chapter has discussed the role of the car in children's travel behaviour, and the possible long-term negative consequences of building in car dependency at an early age. Including the impacts of reductions in levels of physical activity and increasing levels of obesity. Active travel has been suggested as a way to decrease levels of childhood obesity, something that is predictive of both adult obesity and future early mortality and morbidity. Another change that has gone along with a general decrease in the level of walking for children's journeys, is the increased level of adult accompaniment on those journeys.

The possibility that there are psychological impacts was also discussed. Physical activity and active travel modes are linked to a reduction in negative psychological states such as depression and anxiety. In the next chapter we will consider the travel-specific cognitive psychological factors that might be linked to travel mode and independent behaviour.

The school and the journey to school have been chosen as the focus for this research because it is an important part of children's daily routine. It represents a common everyday activity for a large group children. Also, the loss of independence on the journey to school is a marked change in children's lives.

3 Cognitive maps

> …the incoming impulses are usually worked over and elaborated in the central control room into a tentative, cognitive-like map of the environment. And it is this tentative map, indicating routes and paths and environmental relationships, which finally determines what responses, if any, the animal will finally release (Tolman, 1948, p. 192)

> …the concept of space, is for many reasons an indispensable part of child psychology (Piaget & Inhelder, 1948, vii)

This research concerns the ability of young children to represent their local environments. A fundamental component in the processes that allow an individual to store and recall information about spatial relationships is the cognitive map. It is Edward Tolman who is often given credit with introducing the term into the literature (Bennett, 1996; Foo, Warren, Duchon, & Tarr, 2005; Wolbers & Hegarty, 2010) in his 1948 paper "Cognitive maps in rats and men" (Tolman, 1948). His paper focused on the observation that, despite the beliefs of those who described animal learning as "simple stimulus-response connections" (p. 192), the rats in the experiment seemed capable of planning novel routes in response to changes in the environment. This suggested that rather than just relying a narrow set of responses to the environment, the animals had instead constructed, and make their plans with regard to, a map-like representation of the space: "learning consists not in stimulus-response connections but in the building up in the nervous system of sets which function like cognitive maps" (p. 193). It is the focus on the processes that allow the generation of novel travel solutions that links the study of cognitive maps with real world travel behaviour.

This section will cover some of the empirical research, and modelling work, that has been carried out in order to understand the mental processes involved in cognitive mapping.

3.1 The cognitive revolution

Tolman was one of those at the centre of the "cognitive revolution", a term that refers to the intellectual movement that emphasised the importance of studying internal mental processes (Gardner, 1987). When Tolman’s 1948 paper was published the dominant intellectual movement was behaviourism, which dealt with observable behaviours and treated mental processes as unknowable. Behaviourism has now been eclipsed by cognitive psychology, which has become a large discipline within psychology (Eysenck, 1991; Sternberg, 2009). The most important themes from cognitive psychology for this research are those dealing with memory and spatial cognition and behaviour. Over the years many theories have been put forward to explain the processes involved in cognition, from the Gibsonian theories of spatial perception and behaviour (Gibson, 1986), through theories of information processing of Neisser, who is also credited with introducing the term “cognitive psychology” (Neisser, 1967). Neisser is also known for advocating ecological validity in cognitive psychology; this was in opposition to an approach where insights gained in the laboratory are generalised to explain real world behaviours (Neisser, 1976).

3.2 The cognitive processes in spatial knowledge

This chapter presents an overview of cognitive processes involved in children's travel, including the theories of spatial knowledge that describe how information about the environment is stored and recalled. In day-to-day life, people rely on the information stored in cognitive maps to orient themselves in the real world. An individual’s cognitive map can be built up from observations gathered as he or she travels through the environment (Kuipers, 1983). Secondary sources, things that the individual does not experience directly, can also add information to a cognitive map (Presson & Hazelrigg, 1984). Building up a cognitive map involves a process whereby the aspects of environmental knowledge, or secondary knowledge, acquire salience and act to structure other information (Downs & Stea, 1973).

3.3 Spatial representations at different scales

Thinking about space can occur across a wide range of scales. Astronomers are very comfortable working with distances that number in the billions of light years (WolframAlpha, 2011). At the other end of the scale skilled typists can locate all the keys on a keyboard without looking, allowing them to touch type (Rumelhart & Norman, 1982). When an individual is typing their spatial memory is operating over a range of a few centimetres and allowing them to discriminate between the locations of keys to within a few millimetres. There are of course cases, such as watchmaking, where even finer motor control, is evident. In dentistry, similarly fine motor control is called for; this is often complicated by the need to work with a mirror image (Kunovich, 1992).

The experience of children encompasses only a very small part of the universe, and wayfinding does not require the sub-millimetre precision of a watchmaker. Children’s movements in the local environment take place at a scale that has been referred to as ‘everyday space’ (Freundschuh, 1997). One way to divide everyday space is into small-scale and large-scale space. The difference between these categories is that at the small-scale the observer can apprehend all the spatial relations from one point of view, in large-scale space on the other hand the observer must move around the environment to appreciate the spatial relationships. The differentiation between large- and small-scale, can include the difference between completing a test of spatial cognition, which could be based on a small model or an illustration, and the real-world task of navigating an environment (Quaiser-Pohl, Lehmann, & Eid, 2004).

3.3.1 Overgeneralising from small scale spatial tests

It can be tempting to conflate small-scale and large-scale spatial skills, which can lead some to apply findings from psychological tests to real-world behaviours. For instance the findings that men, on average, outperform women on tests of spatial abilities (Voyer, Voyer, & Bryden, 1995) is generalised into the basis for books like “Why men don't listen & women can't read maps” (Pease & Pease, 2001), and newspaper articles with titles like “Why women cannot read maps and men lose their keys” (Alleyne, 2009).

3.3.2 Examples of measures of spatial ability

The diagrams in Figure 3-1 below shows examples of three measures of spatial ability, all of which are administered as ‘paper and pencil’ tests.

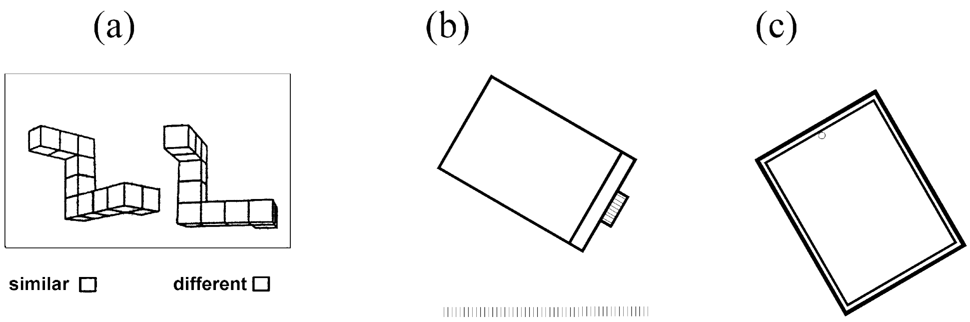


Figure 3-1: Test items from three tests of spatial ability. (a) Mental Rotations Test, (b) Water-Level-Task, (c) Rod-and-Frame Test. Source: (Quaiser-Pohl et al., 2004)

- Mental Rotations Test. The items come from a test of mental rotation, in this test subjects are presented with figures that were either identical, but seen from different angles, or were different, distractor, versions. Distractors in this type of test include mirror image versions of the test item. Test subjects must mentally rotate and attempt to match the objects.
- Water-Level-Task. The Piagetian Water-Level-Task asks subjects to draw a line showing how the surface of the water in each test item would be orientated.
- Rod-and-Frame Test. The Rod-and-Frame Test has its theoretical origin in the research on field dependence/independence (Witkin & Asch, 1948). The paper and pencil version of the test requires test subjects to draw the correct position of a rod hanging from a tilted frame.

These are the types of test where the 'male brain' displays a consistent advantage, with an advantage for mental rotation being one of the most consistent findings (Linn & Peterson, 1985).

The phrase 'male brain' refers to the finding that testosterone levels experienced early in life including, very importantly, the period before birth can have an effect on the structure and functioning of the brain (Knickmeyer & Baron-Cohen, 2006). It has been suggested by Simon Baron-Cohen that disorders on the autistic spectrum are linked to an extreme version of the male brain (Baron-Cohen, 2003), where an enhanced understanding of the systematic mechanics of the physical world, for instance an ability to understand the actions of machines and computer programs, comes at the price of an understanding of the intentions and motivations of other people. The two types of understanding have been called 'folk physics' and 'folk psychology' (Baron-Cohen, 1999).

What is unclear is whether the small-scale tests of spatial ability have a predictive value when considering the large-scale spatial tasks, including wayfinding in the local environment. Quaiser-Pohl et al. (2004) compared paper and pencil tasks with sketch mapping of a real environment results, and found that a distinction should be drawn between small-scale and large-scale tests of spatial ability. It is suggested that the skills required to complete spatial tasks depends on the scale, and there may be no 'male brain' advantage for large-scale spatial tasks, such as wayfinding.

3.4 Neural basis of cognitive maps

Cognitive maps exist as a theoretical construct in cognitive psychology, but there is also evidence that there are physical structures that underpin the operation of the spatial memory and spatial thought (Jeffery & Burgess, 2006; Maguire et al., 2000). It has been known for many years that the hippocampus, a seahorse shaped structure deep in the brain, is involved in memory for space (O'Keefe & Nadel, 1978). It has even been suggested that the underlying neural structure of the hippocampus imposes the order that we perceive as the three dimensional world (O'Keefe, 1993).

3.5 Distortions and errors in cognitive maps

The term cognitive map has been labelled as misleading (Kitchin & Blades, 2002), an individual's cognitive map of an area will not necessarily consist of precise and complete spatial survey of the real environment, what we might think of when we hear the word 'map'. In fact, an important feature of human cognitive maps is that they are often distorted in a systematic way (Friedman & Kohler, 2003; Tversky, 1981). It has been suggested that the distortions in cognitive maps are the result of both "differences in the mobility and idiosyncratic experiences of individuals" and "systematic distortions … caused by the cognitive processes used to code spatial information into memory or to retrieve it from memory" (Lloyd & Heivly, 1987, p191).

The cognitive map is not a direct analogue of the real world. Cognitive maps allow people to acquire, encode, manipulate, store and represent spatial information. Each of these stages is subject to error, or may be only partially completed, depending on competing demands on attention. It is perhaps not surprising then, that when the information that can be recalled from a cognitive map is compared to the real world there are often differences. These errors, or features, of the information stored in the cognitive map include distortion, incompleteness and fragmentation (Siegel et al. 1979; Downs 1981; Buttenfield 1986; Bryant et al. 1992; Tversky 1992).

Cognitive maps can represent the real world, but as they are the product of internal mental processes, which are often unconscious, these representations are not directly observable (Golledge, 1999a). Instead we must rely on indirect methods to probe the contents of the cognitive maps; these methods may contribute to the observed errors.

3.6 Wayfinding and cognitive maps

Often, when the cognitive map is under consideration, it is in connection with wayfinding (Lynch, 1992). Wayfinding refers to the process of planning routes and following them to their destination (Golledge, 1999b).Wayfinding and cognitive maps are often linked in research projects (Bugmann & Coventry, 2008; Hölscher, Büchner, Meilinger, & Strube, 2009), with work often focusing on the nature of cognitive maps, how they are developed, how the knowledge about the environment is structured, and how information is retrieved from them. As this research was prompted by concerns that children may be building in car dependency at an early age, it is the behaviour of independent travel that is of primary interest. Independent travel will be enabled by the efficient wayfinding, and this in turn relies on good quality cognitive representations of the environment.

Cognitive maps, act as internal spatial representations, and are an indispensible element of the cognitive apparatus we use to navigate the world. The information in the cognitive map is employed in wayfinding; there are three primary ways the information can be used to solve a wayfinding task; navigating to landmarks, following routes, or generating a solution from configurational knowledge (Smyth, Collins, Morris, & Levy, 1994). There has been an assumption that moving from landmark navigation, through route navigation to map, or configurational, navigation represents a development from basic to sophisticated navigational skills (Piaget & Inhelder, 1948; Siegel & White, 1975a). These stage theories of wayfinding development are based on work by the highly influential developmental psychologist, Jean Piaget and reflect his staged theory of child development.

The next sections will discuss the proposed levels, or stages of cognitive map knowledge.

3.6.1 Landmarks

Landmarks can include highly visually distinctive objects that are visible from a distance, but this does not need to be the case. So, while Lynch (1960) includes the example of the tower in St Marks Square in Venice as a prominent landmark, he also notes that landmarks can vary widely in scale. The most important qualities for a landmark are that it is possible for the person using it to be able to single it out from the background. The qualities that an individual finds salient and potentially unique may be visible to all, height, colour, lighting, etc., or the qualities may be more personal, the house he or she grew up in, or the office building where he or she first worked.

3.6.2 Routes

Route knowledge can be described as the ability to navigate to landmarks in the right order to reach one's destination (Newcombe & Huttenlocher, 2003). It has been separated from simple knowledge of landmarks, and placed between basic landmark knowledge, and the more cognitively complex, and complete level of knowledge known as survey or configurational knowledge (Siegel & White, 1975b). We can understand route knowledge as the ability to follow previously learnt routes between locations. Boling (2000) gives the example of driving to the shops and then having to drive back home again in order to get to the cinema. The explanation for this behaviour is that the driver in the example only has route knowledge of the environment, and has not yet developed the survey knowledge required to plan a novel route (Boling, 2000).

It has been argued that because of the reduction in independent experience children now lack the linkages between places, because their experience of their environments does not include independent travel, including walking along streets, past familiar people and places between locations (Freeman, 2006).

3.6.3 Configurational knowledge

This is the highest grade of spatial representation; once knowledge about the local environment is held in this way it means that an individual has good knowledge of the distance and direction to all parts of the environment (Kitchin and Blades, 2002). This representation of environmental relations is also referred to as survey, or map knowledge. It can be thought of as allowing an individual an objective frame of reference, freeing them from dependence on limited landmarks and routes. There is some debate about whether or not configurational knowledge only arises as part of a strict progression (Torell, 1990): developing survey knowledge after landmark knowledge and then route knowledge have been acquired.

3.7 Attention during wayfinding tasks

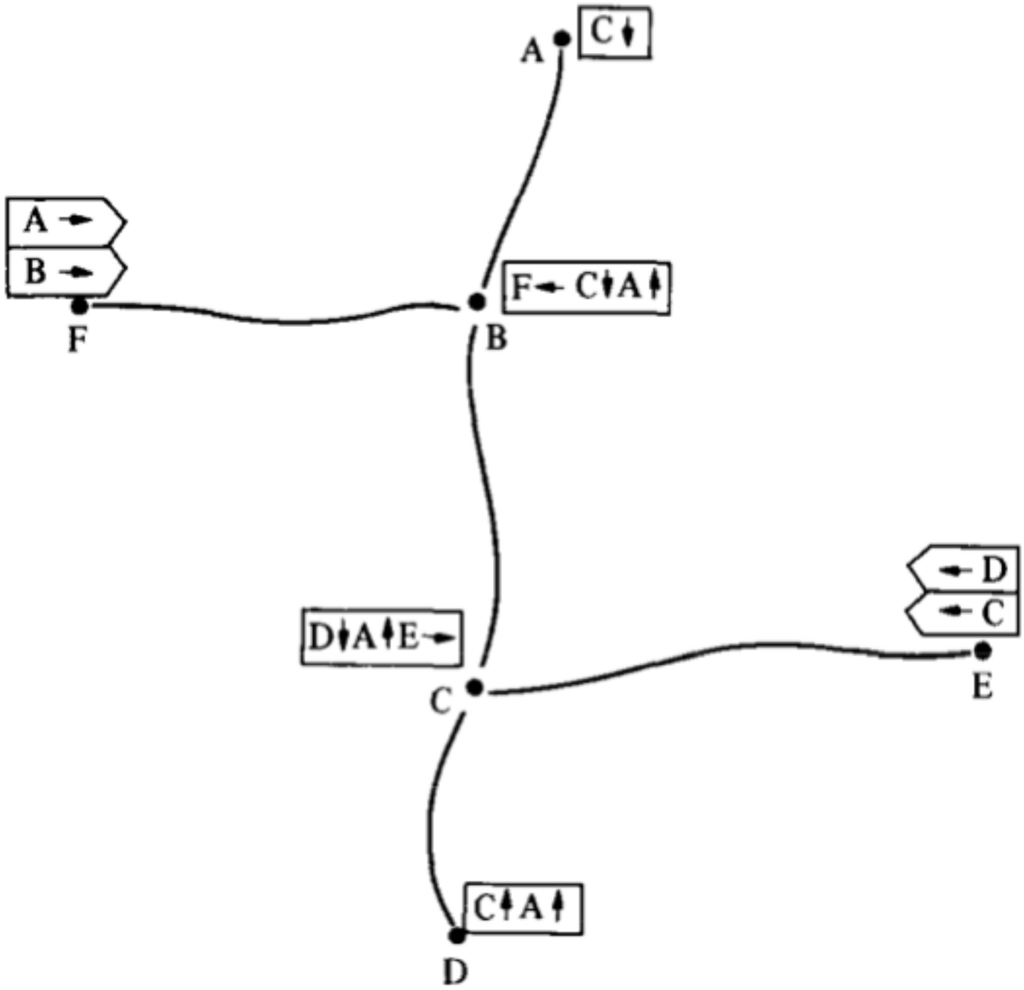
Wayfinding tasks differ in the load they place on "attentional resources" (Montello, 2006); unfamiliar environments impose a very high load. Attention has been studied since psychology emerged as a discipline, for instance in the writings of William James, who characterised it as "withdrawal from some things in order to deal more effectively with others…" (James, 1890, p. 403-4). This early conception of attention recognise the role it plays in allowing us to better perceive, conceive, distinguish and remember (James, 1890). Attention can be paid both to external and internal events and objects, and being able to select what is attended to allows humans to make the best use of their limited cognitive capacity (Neisser, 1967). Studies have investigated the role of attention in cognitive mapping with mixed results. Péruch, Vercher and Gauthier (1995) found evidence that active processing, having to pay attention, conferred an advantage for memory of a virtual environment, however Wilson, Foreman, Gillett, & Stanton (1997), also using a virtual environment, found no evidence of an advantage.

It will be assumed in this work that children who are making walking journeys, especially unaccompanied walking journeys, will have a higher load on their attentional resources than children who are travelling as passengers.

3.8 Computer models of wayfinding

As powerful programmable computers have become readily available, theoretical cognitive models have been developed into computer-based models. There have been attempts to model cognitive behaviour using computers since the earliest days of cognitive psychology (McCarthy, 1959; Thagard, 2010). Two examples of early models of spatial behaviour, are TOUR (Kuipers, 1978), and *the Traveller* (Leiser, 1987). The TOUR model represented spatial knowledge in five categories, including route descriptions, street networks and coordinate frames for relative position. *The Traveller* works by representing spatial knowledge in terms of an action table. Figure 3-2 shows an example of a spatial network (a layout of routes and destinations) and an action table. The action table represents the steps required to travel between any two points in the network (Kitchin & Blades, 2002), so called "condition-actions pairs" (Leiser & Zilbershatz, 1989).

Other work has used computer models with route knowledge to inform the wayfinding behaviour of computer controlled agents, or demons, (McCalla, Reid, & Schneider, 1982). This approach continues with the current use of agent based models (ABMs), which can be combined with modern three-dimensional environmental models (Crooks, Hudson-Smith, & Patel, 2010).



	A	B	C	D	E	F
A			↓			
B	↑		↓			←
C	↑			↓	→	
D	↑		↑			
E			←	←		
F	→	→				

Figure 3-2: The Traveller model's network model and action table

3.9 Cognitive maps and travel behaviour

It has been suggested that the study of cognitive maps play a vital role in the choice of travel mode, and indeed, whether to travel at all (Gärling & Golledge, 2000). The information stored in the cognitive map affects people's travel choices because an individual can only choose between destinations that they are aware of, and he or she will require knowledge about the spatial relations between the start and destination, and between the destinations themselves.

The degree and accuracy of knowledge depend on familiarity with the environment, and are important moderators of these relationships. They argue that complex trips, with multiple stops and/or purposes require more extensive, and more accurate cognitive maps.

Children’s day-to-day travel has been identified as an important factor in their relationship with the local environment (Hillman et al., 1990). Children’s experience of travel, and independent activities, are part of the process that build up their spatial representations. It is the interaction with the environment that occurs while children travel and take part in activities that builds up spatial knowledge, and it is this knowledge that might be considered as instrumental, necessary if not sufficient, for maintaining and expanding children’s independent travel.

3.10 Relationship between the cognitive map and the environment

There is a large degree of interplay between the factors in this relationship, especially when considering independent behaviour. A prerequisite for independent behaviour, such as walking to a friend’s house or visiting the local park, is a representation of the relationships between objects in the local environment. Children must also be able to use this representation to plan a route, and monitor their progress along it. However, it is precisely this kind of activity, independent mobility, that will allow the child to build up the representations, and practise the skills that they will rely on to travel independently, and indeed a lack of autonomous travel behaviour has been found to have an impact on spatial skills (Hart, 1979; Hillman et al., 1990). Figure 3-3, below shows how the child’s local environment and their cognitive map form part of a cycle. It can be appreciated that this cycle has the potential to be virtuous, where experience enriches a skills set, or vicious, where a lack of experience leads to impoverished spatial skills.

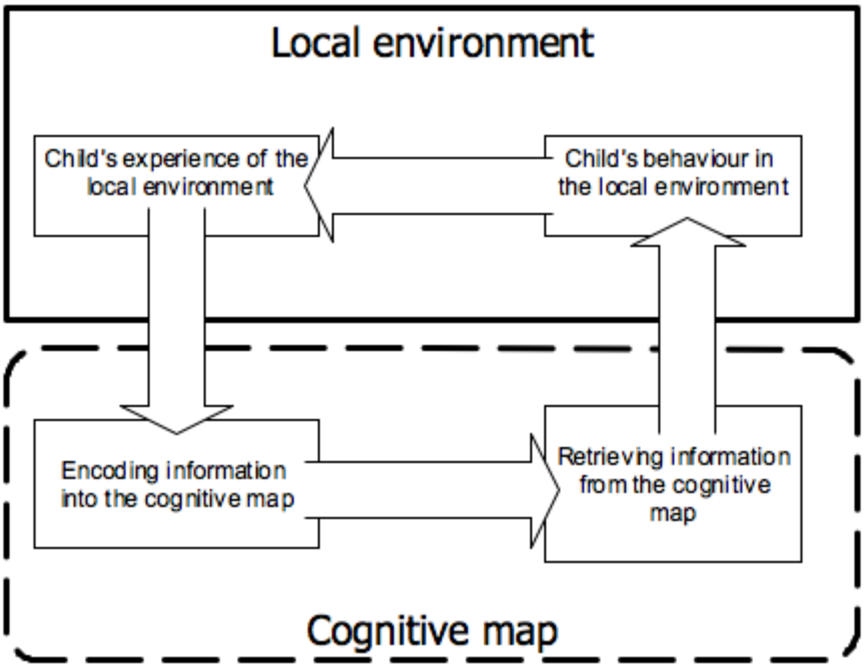


Figure 3-3: The cognitive map and the local environment interact with one another

3.11 Chapter summary

As this research was prompted by concerns that children may be building in car dependency at an early age, it is the behaviour of independent travel that is of primary interest. Independent travel will be enabled by the efficient wayfinding, and this in turn relies on good quality cognitive representations of the environment.

Cognitive maps and the related areas of spatial ability, spatial knowledge and wayfinding, all deal with knowledge of large-scale environments. People are considered to have different levels of familiarity with an environment, preferences for features and a range of wayfinding abilities. The processes involved are not at all clear, leading to a number of debates over how exactly spatial knowledge is stored and structured. The literature on the topic includes a wide range of results, and theories. There is, however, a consensus of opinion that it is interaction with the environment is important in the formation of cognitive maps (Matthews, 1987; Rissotto & Tonucci, 2002; Torell, 1990).

Furthermore an individual's cognitive map has been shown to play a crucial role in planning travel behaviour (Gärling & Golledge, 2000) allowing decisions about travel behaviour to be made.

It seems clear then, that understanding individual travel behaviour, including the travel behaviour of children, would benefit from a richer understanding of the influence of travel behaviour on the detail and accuracy of cognitive maps.

4 Data collection and the study area

4.1 Data collection

The data for this thesis was collected during CAPABLE (Children's Activities, Perceptions and Behaviour in the Local Environment), which was a research project funded by the EPSRC (Engineering and Physical Sciences Research Council). The author worked on CAPABLE as a Research Fellow between 2004 and 2006. The author also worked on a previous project, Reducing Children's Car Use: The Health and Car Dependency Impacts. Some elements of the methodology employed on the Reducing Children's Car Use project were developed and refined for use in the CAPABLE project. The author was involved in the development of the fieldwork tools for both projects, the design of the research schedule, and the data collection in schools.

A large part of the fieldwork for the CAPABLE project involved working with children in the last three years of primary school (between 8 and 11 years old). One of the elements of CAPABLE was a study of children's physical activity and their patterns of movement. Most of the fieldwork for this element of the project was carried out in Hertfordshire, a county to the north of London. There was additional data collection in schools in Lewisham, an area in South East London, during the CAPABLE study. The research work in the Lewisham schools had a slightly different focus from the work carried out in the Hertfordshire schools, so the datasets obtained from the primary school children from the Lewisham schools are not of exactly the same type as the datasets collected in the Hertfordshire schools. However, some instruments, including questionnaires for children and their parents, were used in both locations.

The work presented in this thesis covers a smaller geographic range than the CAPABLE project, which involved a number of schools in different towns in Hertfordshire. The data analysed in this thesis were collected from children in Years 4, 5 and 6 in two schools in Cheshunt that took part in the CAPABLE project: Flamstead End Primary School and Burleigh Primary School.

4.2 Recruiting participants

The process of recruiting schools for the CAPABLE project began at the end of the Children's Car Use project, with a questionnaire sent to schools in Hertfordshire. The questionnaire formed part of the Children's Car Use project and dealt with the walking bus, an initiative designed to overcome the barriers that prevent children walking to school. More details about the walking bus research can be found in (Mackett, et al. 2003).

The walking bus survey was sent to the headteachers of all primary schools in Hertfordshire. The names of all the schools in the county were taken from a spreadsheet supplied by Hertfordshire County Council’s Environment department. The same information is available on the county’s website on the Schools address book page (www.hertsdirect.org/schoolsaddressbook).

A form sent with the questionnaire gave the school the option of indicating that they would be interested in taking part in further research work with University College London. A note was kept of all those schools where the headteacher indicated that they would be interested in taking part in further work. When the CAPABLE project began, those who expressed an interest in future work were contacted again. The letter, sent to the headteachers of all potential schools, is shown in Appendix 1. The letter described the planned fieldwork for the CAPABLE programme, including the CATS (Children's Activity and Travel Study) which would include physical activity and GPS based location monitoring.

The different kinds of monitoring, measurement exercises and classroom-based exercises were mentioned. In the letter, and subsequent communications with schools who replied, the impact on the children’s day-to-day school activities was laid out. The commitment was much more clearly laid out in later communications, when the plan for the fieldwork was more fully developed. Also communicated, was the idea that the fieldwork exercises could be integrated with existing subject areas, and schools were offered the chance to request suitably anonymised copies of the research datasets.

Any interest in the letter was followed up by further contact, which supplied more detail about the nature of the research and the activities that the children would be involved in. Typically a headteacher would get the agreement of the year group teachers and then a visit to the school would be arranged.

During the visit, the author would make a presentation to the whole school, or Years 4 to 6 during an assembly. The presentation covered the planned CAPABLE project, and described the research, the reasons why it was being conducted and the potential outcomes. Importantly, the presentations also included a description of what was involved, in terms of activities and time commitment, for any children who volunteered for the CATS physical activity and GPS location monitoring study.

The presentations to schools also included results obtained from the previous monitoring carried out in the Children's Car Use project. This project dealt with children's physical activity, and did not include GPS based location monitoring. The structure of the monitoring period, including the use of a travel and activity diary (see Appendix 2) is described in Section 4.7. Because of the similarity in the structure of the fieldwork it was possible to show some results, and give the children and their teachers an idea of what would be involved if they took part in the research programme.

A high response rate was not required for this stage, as each school could potentially supply 20–30 participants in each of the three year groups we were interested in.

4.2.1 Recruiting the second school in Cheshunt

The headteacher for Flamstead End Primary School had responded to the initial letter asking for schools to participate in the CAPABLE project. Burleigh Primary School, the second school in Cheshunt involved in the study, was approached while the fieldwork was in progress at Flamstead End Primary School. It was chosen because of its proximity to that school.

Almost all of the data that will be analysed in this thesis involves participants from the two primary schools in Cheshunt. One exception is the data from the pilot study which was gathered at primary schools in Broadfield, West Sussex and Rossington, South Yorkshire.

4.3 About the study area

The map in Figure 4-1, shown below, indicates the position of Cheshunt within the UK. Cheshunt is a town to the north of London and lies on the Hertfordshire side of the border between the counties of Hertfordshire and Essex. Cheshunt is part of the Borough of Broxbourne and is in London's commuter belt.

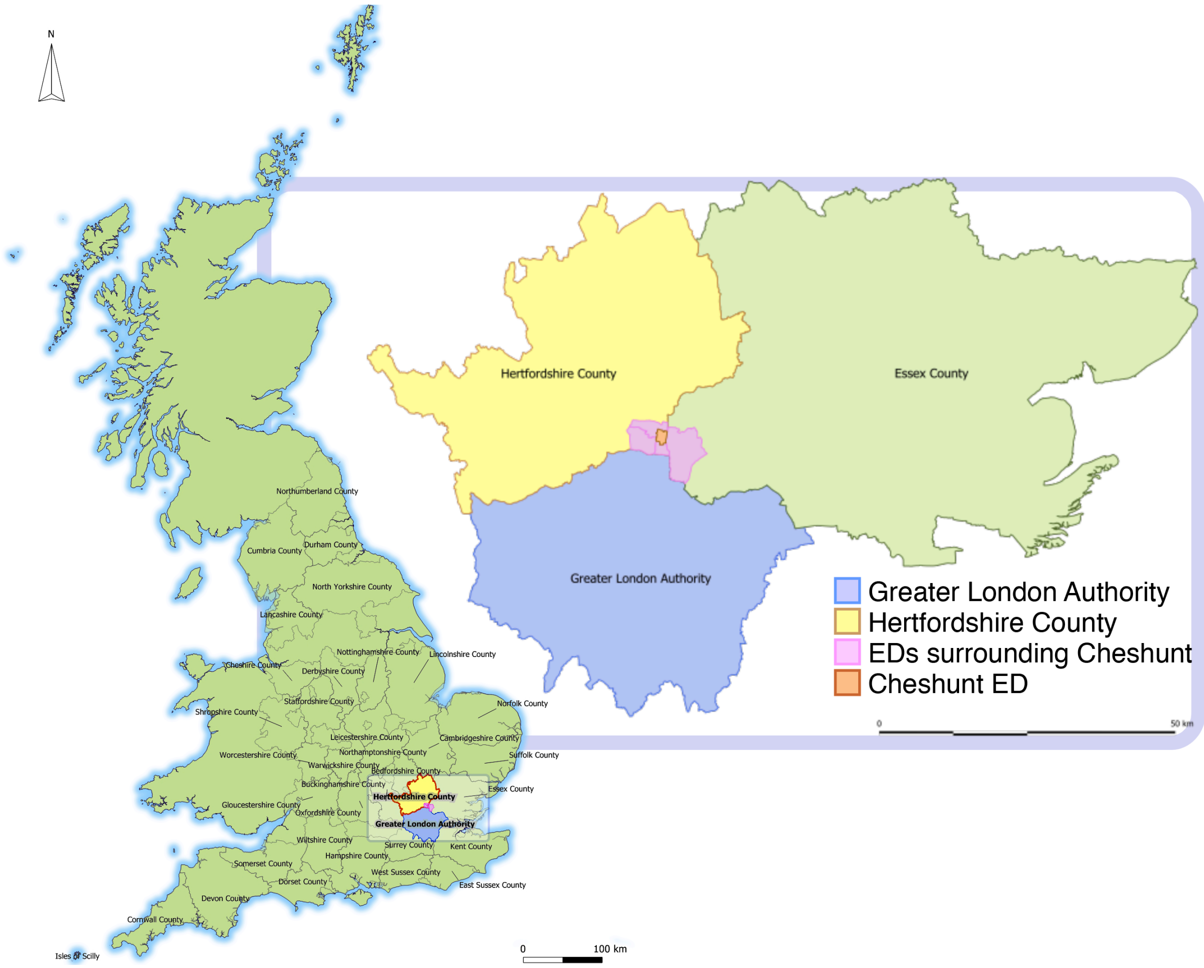


Figure 4-1: Location of Cheshunt, in the County of Hertfordshire to the North of London (ED – enumeration district)

Cheshunt has good transport links via rail and road. In 2004 Cheshunt railway station was one of the top 10% most used stations in the country according to a survey carried out by the Office of Rail Regulation. This figure for use is based on the total number of entries to the station; Cheshunt station was 210th in a list of 2501 stations considered in the survey (Office of Rail Regulation, 2006). It is likely that many of those journeys were for work in London as Cheshunt lies within the London Travel to Work Area (TTWA). TTWAs are defined by Office for National Statistics and group locations that have a strong commuting link between them (Bond & Coombes, 2007). The position of Cheshunt within the London TTWA is shown in Figure 4-2 below. Cheshunt also has good road links; it is located on the A10 (also known as the Great Cambridge Road), which links Cheshunt to the M25 Motorway and London in the south, and King's Lynn via Cambridge to the north.

Figure 4-2: Map showing the position of Cheshunt in the London Travel to Work Area, which is indicated by dark blue shading

In common with other towns with good transport links to the capital, Cheshunt has been described as a dormitory town, indicating a large number of people live in the town but commute to work in London. Local employers include Tesco, a company that reported pre-tax profits of over £2 billion in 2005 (Tesco, 2005), who have their head office in the town.

The Office for National Statistics includes Cheshunt within the Greater London Urban Area in the 2001 census (Office for National Statistics, 2004). The 2001 census estimated that the population of Cheshunt was 55,275, of which 2.8% were in the age range 8 – 9 years old and a further 6.6% were in the age range 10 – 14 years old. The children who participated in this study were between 8 and 11 years old.

Table 4-1, shown below, compares the population of Cheshunt with the population of the Greater London Urban Area and England and Wales. It can be seen from Table 4-1 that the proportion of children in the 8 – 9 and 10 – 14 year ranges are very similar to the Greater London Urban Area and England and Wales as a whole. It can also be seen that the average person in Cheshunt is older than the average person in the Greater

London Urban Area. However the median age in Cheshunt matches England and Wales as a whole.

Table 4-1: Population size and proportion in the age groups of interest for Cheshunt, the Greater London Urban Area and England and Wales (Office for National Statistics, 2004)

	Whole population	**Percentage of people aged:** 8 – 9	10 – 14	**Median age**
Cheshunt	55,275	2.8	6.6	37
Greater London Urban Area	8,278,251	2.5	6.1	34
England and Wales	**52,041,916**	**2.6**	**6.6**	**37**

When considering car and van ownership for the same areas there are some differences. Table 4-2, shown below shows the number of households in Cheshunt, the Greater London Urban Area and England and Wales as a whole, along with the figures that describe car ownership levels for those areas. It can be seen that car ownership is higher for Cheshunt than either the Greater London Urban Area or England and Wales. The number of households without a car or van is much lower in Cheshunt at 18.8%, than in either the Greater London Urban Area at 34.8%, or England and Wales 26.8%.

Table 4-2: Number of households and car and van ownership for Cheshunt, the Greater London Urban Area and England and Wales (Office for National Statistics, 2004)

	All households	**Percentage of households (number of cars or vans)** 0	1	2	3	3+	**All cars and vans in the area**
Cheshunt	22,447	18.8	42.6	29.6	6.8	2.1	29,516
Greater London Urban Area	3,469,373	34.8	43.0	17.9	3.4	1.0	3,233,820
England and Wales	**21,660,475**	**26.8**	**43.8**	**23.5**	**4.5**	**1.4**	**23,936,250**

Considering the good public transport links between London and Cheshunt, it is likely that households will have a car available for other journeys during the week, including the journey to school.

4.4 About the schools

A decision was made to target two schools in the same town, with the expectation that the children would share a large number, perhaps the majority, of landmarks, and that this would simplify the process of matching real-world and sketched landmarks.

Flamstead End Primary School was the first school to be involved in the research, and was recruited at the beginning of the CAPABLE project. Burleigh Primary School was encountered on the walk from Cheshunt Railway Station to Flamstead End Primary School. The two schools are similar in many respects, including age groups and class sizes, and both schools have two forms in each school year.

Figure 4-3, shown below, gives address details for Burleigh Primary School and Flamstead End Primary School along with a small map showing the main building and the immediate area around it for both schools. Both primary schools are located in Cheshunt, but are in separate wards; see Figure 4-4 below. Flamstead End Primary School is in the Flamstead End Ward and Burleigh Primary School is in Cheshunt Central Ward.

Burleigh Primary School (Cheshunt Central Ward)	**Flamstead End Primary School (Flamstead End Ward)**
Blindmans Lane Cheshunt Hertfordshire EN8 9DP	Longfield Lane Cheshunt Hertfordshire EN7 6AG
	

Figure 4-3: Address details for the two schools used for data collection

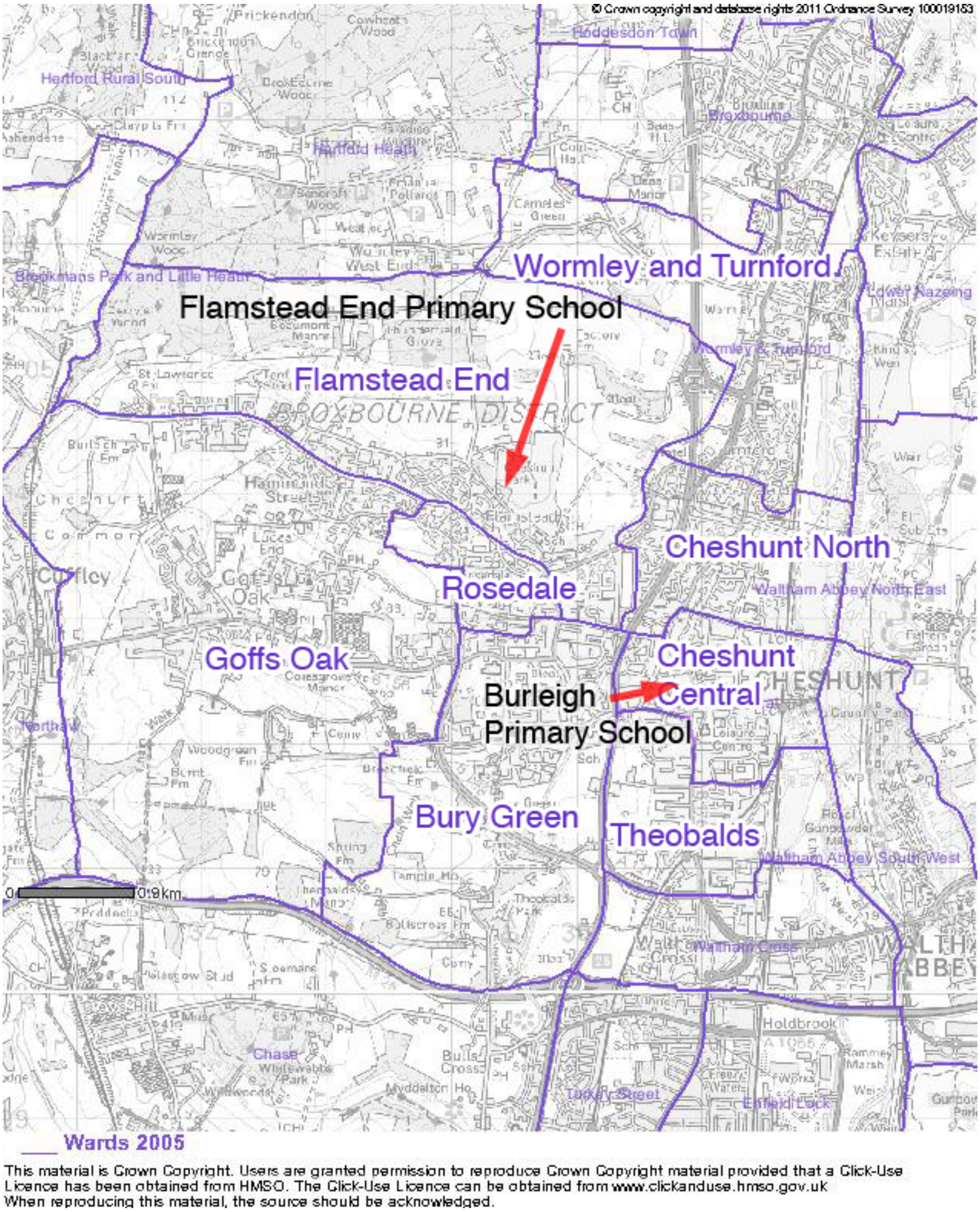


Figure 4-4: Map showing ward boundaries and the locations of the two primary schools

Table 4-3, below, shows figures for selected land use categories for the wards in and around Cheshunt. It can be see that Flamstead End is larger and is less densely populated than Cheshunt Central (the ward containing Burleigh Primary School), as a consequence it has much more greenspace. Although Cheshunt Central has a greater amount of space devoted to gardens than Flamstead End (31.6% compared to 9.4%), the ratio of garden area to housing area is similar for both wards (3.2 and 3.4).

Table 4-3: Land use percentages for wards in and around Cheshunt (Communities and Local Government, 2007)

	Total Area ($x1000\ m^2$)	Percentage of area that is: Domestic Buildings	Road	Path	Domestic Gardens	Greenspace
Flamstead End	9,205	2.8%	3.5%	0.1%	9.4%	81.1%
Cheshunt Central	1,152	9.9%	12.2%	0.6%	31.6%	23.6%
Cheshunt North	1,947	9.0%	12.8%	1.1%	25.6%	26.1%
Goffs Oak	9,538	2.1%	2.7%	0.1%	8.6%	83.2%
Rosedale	667	12.2%	15.6%	1.4%	29.4%	35.0%
Bury Green	4,809	3.3%	5.1%	1.5%	10.9%	74.8%
Wormley And Turnford	3,709	4.1%	6.0%	0.7%	12.2%	65.9%
Theobalds	1,356	9.3%	11.2%	1.1%	30.6%	38.3%
England	**132,323,721**	**1.1%**	**2.3%**	**0.1%**	**4.1%**	**87.7%**

Flamstead End Primary School is near to a large park and golf course, accounting for a large part of the green space described in Table 4-3. Both schools are near to high concentrations of housing. Because of its proximity to the centre of Cheshunt the land use around Burleigh Primary School is more mixed, with a large number of shops and businesses in the local area.

Table 4-4 below shows the ranks for the Indices of Multiple Deprivation (IMD) and the Child Poverty Index of the IMD at the level of the wards in and around Cheshunt. It can be seen that Flamstead End ranks higher on the overall measure, but lower on the Child Poverty Index. The ranking for IMD runs from 1, the most deprived, to 8414, the least deprived, so it can be seen that neither ward rank high for deprivation.

Table 4-4: Indices of Deprivation Rank (2000) at Ward level

	Indices of Multiple Deprivation Rank	**IMD Child Poverty Index Rank**
Flamstead End	5899	5123
Cheshunt Central	6487	4676
Cheshunt North	4354	3554
Goffs Oak	7000	7413
Rosedale	4217	2850
Bury Green	2957	3293
Wormley And Turnford	3820	2519
Theobalds	4472	3469

The two schools are within 2 km of each other, but they are not the closest neighbours. It can be seen in Figure 4-5 that there are other Primary Schools, coloured light blue, that are closer to both schools. However, it was thought that the two schools would still be close enough to share a similar urban environment and mix of pupils.

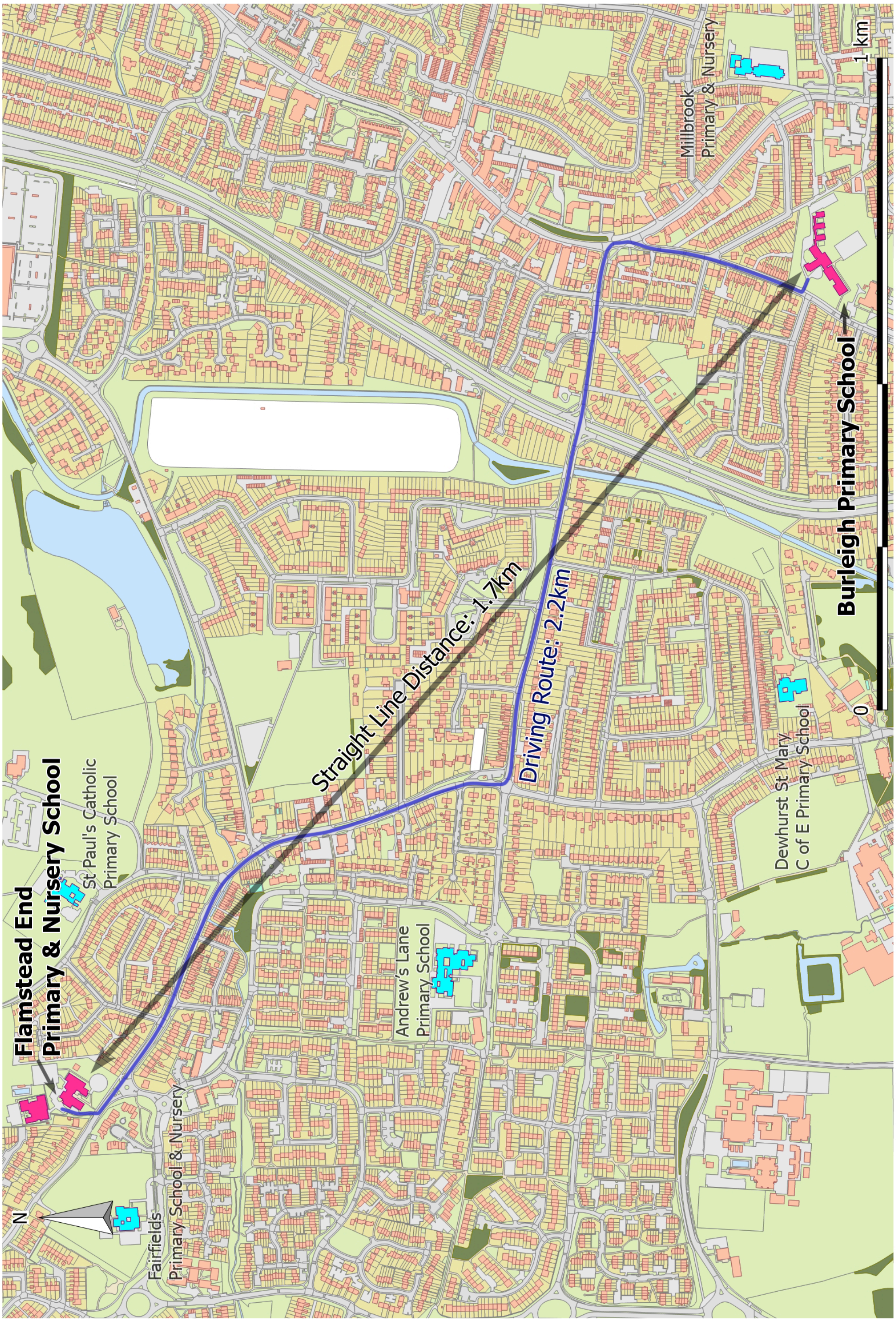


Figure 4-5: Map of Cheshunt showing both schools

The following figures (4-6 and 4-7) show the two school buildings and their immediate surroundings in more detail, Figure 4-6 shows Burleigh Primary, and Figure 4-7 shows Flamstead End.

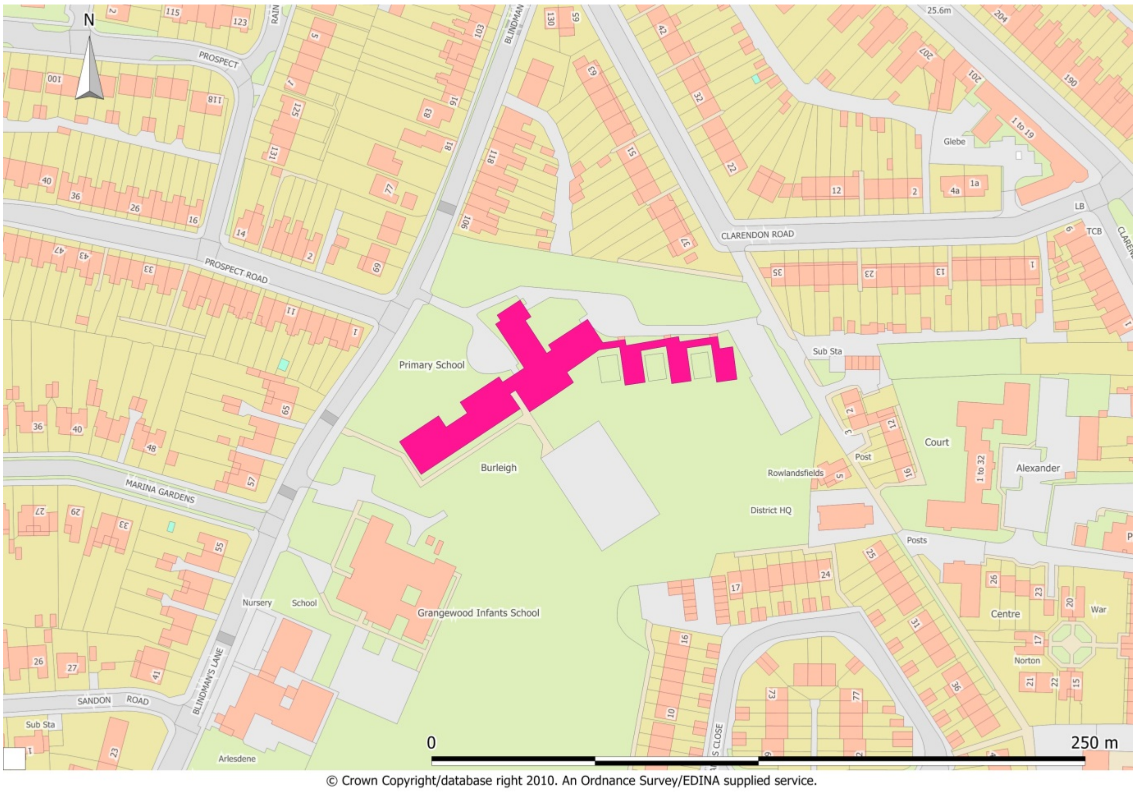


Figure 4-6: Burleigh Primary School in Cheshunt Central Ward

Figure 4-7: Flamstead End Primary School in Flamstead End Ward

Table 4-5, shown below, gives car and van ownership levels for the two wards, and compares them with the overall Cheshunt figures. It can be seen from the percentages in Table 4-5 that there are more households with at least one car in the ward of Flamstead End (88.7%), where Flamstead End Primary School is located, than in the ward of Cheshunt Central (78.8%), where Burleigh Primary School is located.

Table 4-5: Comparing car ownership levels for the wards of Flamstead End and Cheshunt Central (Office for National Statistics, 2004)

	All households	Percentage of households (number of cars or vans) 0	1	2	3	3+	All cars and vans in the area
Flamstead End Ward	2419	11.3	36.5	38.2	10.3	3.6	3880
Cheshunt Central Ward	3042	21.2	45.4	26.1	5.4	1.9	3702
Cheshunt	22,447	18.8	42.6	29.6	6.8	2.1	29,516
Greater London Urban Area	3,469,373	34.8	43.0	17.9	3.4	1.0	3,233,820
England and Wales	**21,660,475**	**26.8**	**43.8**	**23.5**	**4.5**	**1.4**	**23,936,250**

Table 4-6, shown below, gives the percentage of households with different numbers of dependent children. In England 29.4% of households contain at least one dependent child. In Cheshunt Central, the ward for Burleigh Primary School this figure is slightly lower at 28.0%, for the ward of Flamstead End it is much higher at 37.3%

Table 4-6: Comparing numbers of children in households in the wards of Flamstead End and Cheshunt Central (Office for National Statistics, 2004)

	All households	Percentage of households (number of dependent children) None	One	Two or more
Flamstead End Ward	2420	62.7	13.1	24.2
Cheshunt Central Ward	3043	72.0	11.1	17.0
England	**20,451,427**	**70.6**	**12.3**	**17.1**

4.5 Summary of differences between the areas

Although the two schools were chosen with the assumption that their close proximity would equate to similar environments, it has been seen that there are a number of differences. Although they are within walking distance of each other, Burleigh Primary School is in a ward with lower car ownership and a lower proportion of households with children than Flamstead End Primary School. Flamstead End has a lower density of domestic dwellings and more greenspace than Cheshunt Central. The area around Burleigh Primary School features a greater mix of building types, including shops and businesses, than Flamstead End Primary School where the buildings are mainly residential. Table 4-7 summarises some indicators for the two areas.

Table 4-7: Summary of the difference between the wards surrounding Burleigh Primary School and Flamstead End Primary School

	Burleigh Primary School	**Flamstead End Primary School**
Size of ward	1,152,000 m^2	**9,205,000 m^2**
Area of homes	**9.9%**	2.8%
Area of gardens	**31.6%**	9.4%
Area of roads	**12.2%**	3.5%
Area of paths	**0.6%**	0.1%
Area of green spaces	23.6%	**81.1%**
Households with at least one car	78.8%	**88.7%**
Households with at least one child	28.0%	**37.3%**
Indices of multiple deprivation rank	6487	**5899**
Child poverty index rank	**4676**	5123

4.6 The CAPABLE project

The CAPABLE project was designed to produce a highly detailed picture of children's energy expenditure and their activities in the local environment. Small, wearable sensors for position (using Global Positioning Satellites – GPS) and physical activity (using accelerometers) were used to capture the data on children's movement and their physical activity. In addition to the electronic monitors, diaries for travel and activity, and questionnaires were employed to build up a picture of children's travel and other activities. More details about this project, including selected publications and reports, can be found on the project web pages at www.casa.ucl.ac.uk/capableproject.

The main dataset for this thesis was obtained by analysing children's sketch maps. As part of the study children at the Cheshunt schools drew two maps, one showing a route to school, and another showing the area around the school.

4.6.1 Choice of participants

The participants in this research were primary school children in Hertfordshire. All of the children were in the last 3 years of primary school: years 4, 5 and 6. The children's ages range from 8 to 11, the average age for the children in each year group is shown below in Table 4-8.

Table 4-8: Average age of the children

	Boys	Girls	Both sexes
Year 4	8.6	8.7	8.6
Year 5	9.8	9.8	9.8
Year 6	10.7	10.5	10.6

It was felt that the end of primary school was an important stage for the children, both in terms of their developmental progress, and in the lead up to the change from Primary to Secondary school. The lowest age group (Year 4) was chosen because they were thought to be old enough to understand and follow the instructions associated with the questionnaire and other tasks. Pilot fieldwork allowed the investigator to confirm that children in Year 4 were able to understand the instructions given, complete the fieldwork tasks satisfactorily and provide data that could be analysed (Paskins, 2005).

The last three years in primary school are an interesting time, and were chosen because the children are approaching an important transition. The most obvious change they are approaching is that at the end of Year 6 the children will leave primary school and go to a secondary school. In many cases the change from primary to secondary school will involve travelling further to get to a larger school. Each primary school serves relatively small numbers of children; there are over 17,000 maintained primary schools in England (Department for Education, 2009), and consequently many people live reasonably close to one. Secondary schools are much larger and much less numerous, consequently people, on the whole, live further away from them. As children progress through primary school, and they get closer to the point where they will make the transition between types of school, parents will have to face the prospect of their child making a longer journey. In many cases the progression through primary school children's licence to behave, and travel independently, is increased. For instance they may be reaching he point where their parents will expect, or let, them start making journeys (like the journey to school).

The last three years of primary school are a time when the average child's mobility is on the increase (Harloff, Lehnert, & Eybisch, 1998; Hart, 1979; Hillman et al., 1990). This increase in mobility is seen in the sample used for this research, Figure 4-8 (below) shows the percentage of children who answered 'yes' when asked 'Are you allowed to go for a walk on your own?'.

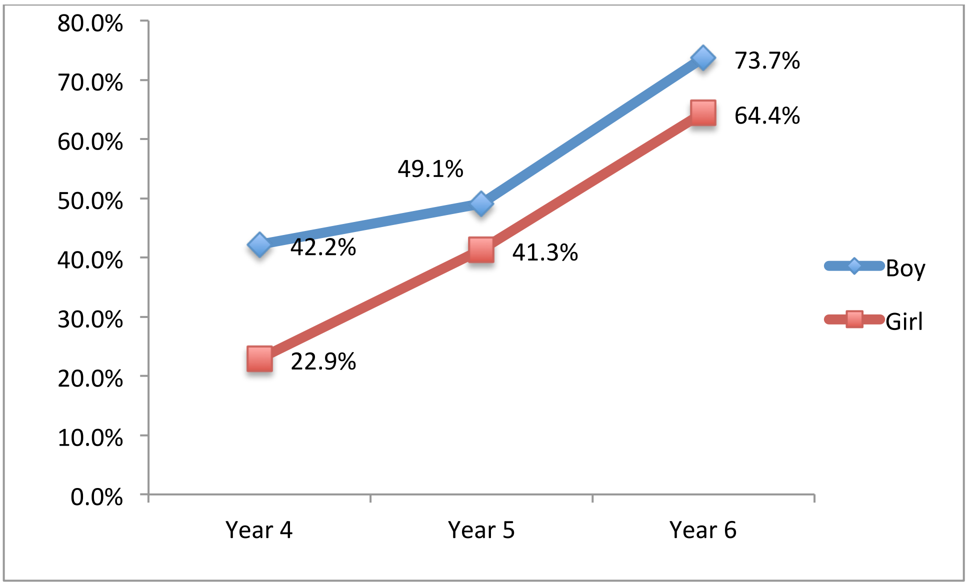


Figure 4-8: Percentage of children in each school year who go for a walk on their own (Source: CAPABLE questionnaire)

The children are also approaching a transition in Piaget's scheme of cognitive development, according to Piaget the change from the Concrete Operational Stage to the Formal Operational Stage, which occurs at around the same age as children go to secondary school. The change from primary school to secondary school often involve changes in the ways that children travel, the distances are typically longer.

The choice of sample, and the location of the fieldwork, was a compromise between the need to find a population that showed variation in their day-to-day behaviour, and the practical considerations of getting responses from a sufficient number of children.

4.7 Data collection

This section sets out the timetable for the data collection carried out for the CAPABLE project. The data recorded by the children in their travel diaries and with their GPS unit has been used in the analysis.

4.7.1 CAPABLE fieldwork timetable

The timetable for data collection for the Reducing Children's Car Use project studies followed the same pattern as the CAPABLE projects, except that CAPABLE added location data monitoring.

An initial visit was made to describe the project to the school and distribute consent letters.

Table 4-9 Timetable for fieldwork

Fieldwork Day	Type of day	Work carried out
Day 0 (Wednesday)	Weekday	Initial Setup: • Consent slip • Height, weight and body fat measurement • Instructions given for filling in the diary and using the monitoring equipment
Day 1 (Thursday)	Weekday	First day of monitoring
Day 2 (Friday)	Weekday	Second day of monitoring • Check diary and equipment
Day 3 (Saturday)	Weekend	Third day of monitoring
Day 4 (Sunday)	Weekend	Fourth day of monitoring
Day 5 (Monday)	Weekday	End of monitoring • Collect the equipment and diaries • Process data to produce activity graphs (both studies) and maps (CAPABLE only)
Day 6 (Tuesday)	Weekday	Feedback session • Fill in missing spaces in the diary • Label unidentified spikes of activity and GPS traces

Additional classroom exercises, including questionnaires and sketch mapping exercises were carried out by whole classes and had to fit in with planned lessons and exams.

4.7.2 Day 0

In addition to the consent letter, signed by the child's parent or guardian, all the children were asked to sign a consent form before the height and weight measurement on Day 0. Children were able to opt out of any part of the study at any point.

After consent had been received the children were asked their name, age and date of birth, the child's sex was also recorded. Then basic anthropometric measurements, height, weight and body fat were then taken. To do this the children were first asked to take their shoes off, they then had their height measured using a stadiometer. The children were asked to take their socks off as well so that their body fat could be estimated using a set of Tanita BIA (Bio Impedance Analysis) scales. As well as weighing the child, the scales use the impedance of the legs to a small current to make an estimate of the child's body fat, bare feet are needed in order to make the electrical connection. It was necessary to record the child's age, height and sex before the measurement was made, as this information, along with the child's weight is used to convert the impedance measurement into estimates of total body water and body fat percentage, only the measurement of body fat was recorded. In some cases a bandage or cast meant that it was not possible to make this measurement, in these cases the child was included without recording his or her body fat percentage, but it was still possible to measure the child's weight in these cases.

The measures of height and weight, along with the child's age and sex were necessary to initialise the RT3 units (Research Triaxial Tracker). A laptop running Windows XP was used to set up the units over a serial connection to the unit's docking station, the same computer and docking station were used to download the data. The data entered during the setup was used to make an estimate of resting metabolic energy consumption and also to convert the movement data recorded by the unit into estimates of the energy expended by the child's movement.

The final piece of equipment was the GPS unit. After an exhaustive search of GPS units the Garmin Foretrex 201 was found to be the best compromise between features, ease of use, weight, size and battery life. The decision to use the Foretrex is covered in more detail in Appendix 3.

Figure 4-9: Picture showing a child wearing the electronic monitors

An example of a child wearing an RT3 unit (worn in a custom made neoprene belt with integrated pouch) and a wrist mounted GPS unit can be seen above in Figure 4-9.

It was recognised that as the procedures described above would involve physical contact with children, some care should be taken in the design of the methodology. Because of this the door to the room used for the measurements was always left open, and the researcher was never alone with a child. All the researchers involved in the fieldwork had a full Criminal Records Bureau check.

4.7.3 Day 1

This was the first day of monitoring. Children wore the monitors, and completed the diaries as instructed.

4.7.4 Day 2

This was the second day of monitoring. Children continued to wear the monitors, and completed the diaries as instructed. The fieldwork team also visited the school to deal with any problems associated with the equipment. The diaries and equipment were checked to identify any problems. The fieldwork team checked that the monitors were still functioning. If necessary the team were able to replace faulty equipment or remind how the child how to use properly and check that the diaries are being filled in correctly

4.7.5 Days 3 and 4

Monitoring continued over the two days at the weekend.

4.7.6 Day 5

This was the end of the monitoring session. The equipment and diaries were collected. Data from the monitors was downloaded and returned in a form necessary for the feedback session.

4.7.7 Day 6

This day was the feedback session, it was an opportunity for the researchers and the participants to fill in any missing spaces in the diary, and to try to explain any spikes of activity and unexplained GPS traces. All the children who took part, and returned the equipment were given a feedback session.

4.7.8 Timing of the questionnaire and sketch mapping exercises

The pupil questionnaire and the sketch mapping exercises, took place at other times in the school year. Where possible the questionnaire and the sketch mapping tasks were administered in a single lesson, when this was not possible the investigator arranged a future visit to complete the fieldwork.

4.7.9 Data collection during the Children's Car Use project

This project coincided with the initial stages of the PhD, and includes the initial pilot work used to determine a methodology that provided usable data.

Pilot work was carried out in schools in Rossington, a village in South Yorkshire and Broadfield a neighbourhood of Crawley in West Sussex. Results from these pilot studies are discussed further below.

4.8 CATS Diary

The diary was given to the children so that that they could make a record of their travel and activities over the course of a four-day period. Children were asked to record details of all the destinations that they visited, starting when they got up on a Thursday morning and ending when they went to bed at the end of Sunday. As well as recording details of the destinations the children also filled in details of the activities that they took part in while at those destinations, and how they travelled between each destination.

An example extract from the diary is shown in Figure 4-10. The events from the diary were mapped onto the output traces from the RT3s, and also onto the location data recorded by the GPS units worn by the children. This meant that it was possible to identify possible omissions from the diary. All the children took part in a feedback session, during which they were given copies of their own data, this session also allowed the researcher to attempt to fill in missing events from the diary, using any spikes of activity or unexplained GPS traces as prompts.

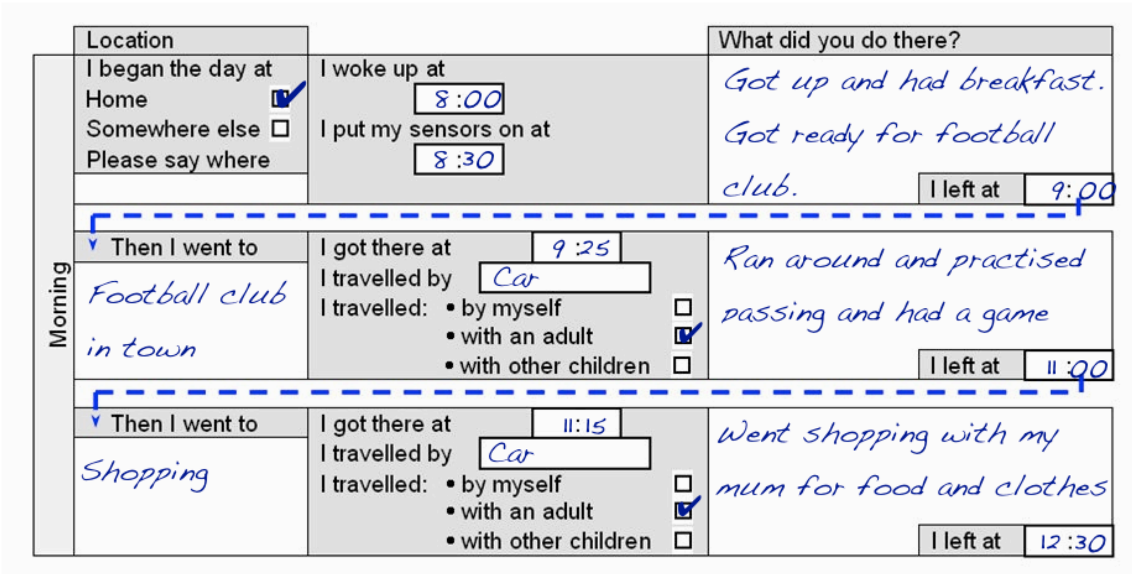


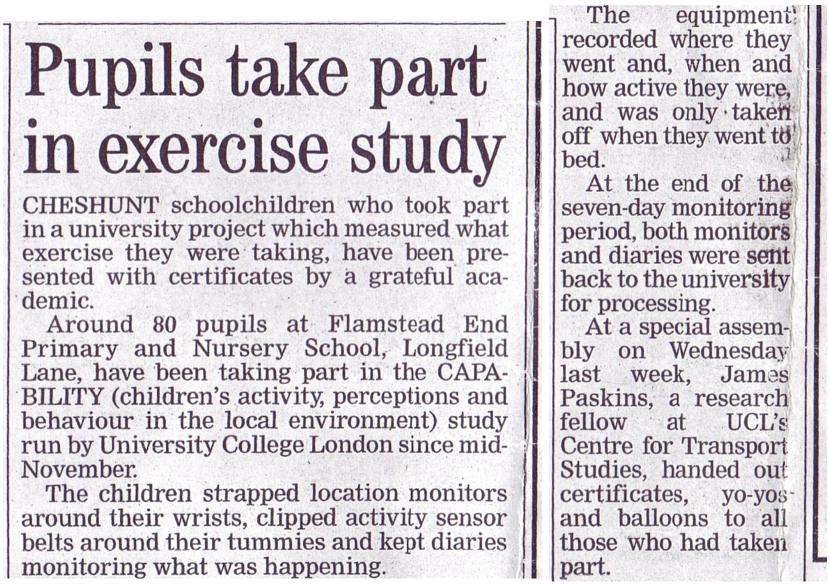
Figure 4-10: Example of a CATS (children's activity and travel survey) diary

The timing for the events and journeys were recorded in a database, and similar activities were grouped into higher-level categories. As well as categories for different modes of travel, the children’s activities were grouped into categories that included, structured activities (including sports lessons), unstructured activities (including playing with friends), shopping and being at home.

The diary also provides details for who is accompanying a child on a journey, and the purpose for a particular journey. The main use of the diary in this research was to provide durations for the different types of activities, including walking and travelling by car, that the children in the sample took part in.

4.9 Feedback from the schools

The fieldwork timetable for the CAPABLE project and the sketch mapping exercises for this thesis were very time consuming for the schools. The questionnaire and sketch mapping exercises involved entire classes, and the monitoring study caused disruption because of children leaving and returning to the classroom. The schools, however, were very supportive of the fieldwork and recognised a value in being involved in the research. There was only one case, a clash between sketch mapping exercises and the run up to mock exams, that resulted in children not completing a sketch mapping task. The children reported that they enjoyed taking part, and they were interested in the feedback that they received: maps and graphs from the electronic monitors. Involvement in the study demonstrated measurement, data collection and the presentation of results in the form of individual feedback maps and graphs. The issues raised by involvement in the study were a good fit with National Curriculum subjects including Geography and PSHE. Something else that might be considered as a benefit to the school was coverage in the local press (Hertfordshire Mercury, 2005). Figure 4-11 shows a news story about the fieldwork in Flamstead End Primary School, it is clear from the story how happy the author was to get participants; it also shows some of the inducements offered for participation.



Pupils take part in exercise study

CHESHUNT schoolchildren who took part in a university project which measured what exercise they were taking, have been presented with certificates by a grateful academic.

Around 80 pupils at Flamstead End Primary and Nursery School, Longfield Lane, have been taking part in the CAPABILITY (children's activity, perceptions and behaviour in the local environment) study run by University College London since mid-November.

The children strapped location monitors around their wrists, clipped activity sensor belts around their tummies and kept diaries monitoring what was happening.

The equipment recorded where they went and, when and how active they were, and was only taken off when they went to bed.

At the end of the seven-day monitoring period, both monitors and diaries were sent back to the university for processing.

At a special assembly on Wednesday last week, James Paskins, a research fellow at UCL's Centre for Transport Studies, handed out certificates, yo-yos and balloons to all those who had taken part.

Figure 4-11: Local news story about the fieldwork in schools

4.10 Chapter summary

This chapter described the data collection procedure for the CAPABLE project, and the additional data collection that was carried out for the PhD research. Some datasets were used for both the EPSRC funded research and the research for this thesis, including the questionnaire, GPS and travel diary data. It has been noted that this number of fieldwork activities caused some disruption for the schools involved in the research, but that schools felt they benefitted from hosting the research.

The author was involved in the development of all the original research instruments for the CAPABLE project. The results presented in this thesis use a combination of the CAPABLE instruments and the instruments developed solely for this research. Results from the GPS are discussed in Chapter 5, a factor analysis of the child questionnaire is described in Chapter 7, and results from the travel diaries are used to study children's travel behaviour in Chapter 10.

This chapter also went into some detail about the area in which the research took place. As has already been noted, the schools were chosen with an expectation that there would be in broadly similar areas, and that the children would share many of the same landmarks. The area around Burleigh Primary School features a greater mix of building types, including shops and businesses, and is more densely populated than the area around Flamstead End Primary School, which has much more green space.

5 Piloting the fieldwork instruments

This chapter will deal with a number of fieldwork instruments that were trialled and developed during the research. The techniques include measures of spatial knowledge, and measures for children’s travel and activity; which included exploring the possibility of using portable GPS units to provide accurate timings and routes for children’s journeys.

The first part of this chapter (sections 5.1–5.6) deals with the process used to pilot different ways to measure the children’s knowledge of their local environment. Sections 5.1–5.6 describe a selection of potential methods, including results from the initial pilot fieldwork, and gives the reasons why sketch mapping tasks were selected as the main outcome measure.

The second part of the chapter (sections 5.7–5.9) covers the analysis of GPS data collected during the research, and assesses its potential to provide detailed information about children’s journeys.

5.1 Sketch maps as a research tool

Sketch maps, are a research tool that are frequently used in order to make explicit, and externalise, the understanding of the environment that the child holds as a cognitive understanding of an environment (Kitchin & Blades, 2002). As has been previously noted, cognitive maps, and the maps that people sketch are very different from standard maps. The sketched maps are generally distorted, in possibly interesting ways, and an individual would be very unlikely to produce a ‘complete’ sketch map, unless a very simple environment was being represented. Furthermore, there is no guarantee that the distances between objects are reliable, even if ordinal relationships are maintained it is unlikely that the map will be drawn to one overall scale. It is more likely that the distances between objects will be stretched and squashed in a non-linear fashion.

It will almost certainly be the case that the distortions present in the representations will vary from person to person. In this research it is these differences that provide the dependent variables for analysis.

5.2 Sketch maps and the child’s school

Both sketch mapping tasks had their focus on the child’s school rather than their home. The first sketch mapping task was the Route Sketch Mapping Task (RSMT), which asked children to draw the route between their home and the school, the second task was the Area Sketch Mapping Task (ASMT), which asked children to draw a representation of the area around their school. Choosing the area around the child's home as the focus for test of local knowledge may have allowed the children the opportunity to recall information about an environment that was more familiar to them. However, the school was selected as the focus for both tasks as it was thought that this common focus would aid the analysis of the resulting maps across the different children.

5.3 Piloting the tests of spatial knowledge

Before the main fieldwork was carried out in Cheshunt, Hertfordshire, a series of piloting exercises were undertaken. There were two early pilot fieldwork sessions that had particular importance for the development of the measures of spatial knowledge used in this investigation.

The first session of pilot work was carried out at Broadfield East Junior School (Broadfield, West Sussex); this was followed by a session in St Joseph's RC Primary School (Rossington, South Yorkshire). The first piloting session introduced the Route Sketch Mapping (RSM) task and the initial version of the travel questionnaire. The second piloting session introduced an additional sketch-mapping task, the Area Sketch Mapping (ASM) task, and tested measures of spatial knowledge that relied on a series of pre-selected landmarks.

All of the fieldwork, including the pilot fieldwork, was carried out in a classroom setting. The pilot fieldwork was an important opportunity to see how the children coped with the fieldwork tasks, as there was a concern that the tasks, including the questionnaire, may be too difficult for the children in Year 4 of primary school. During the pilot fieldwork assistance in administering the tasks was provided by the classroom teacher, and in some cases, a teaching assistant.

During the recruitment of samples for both the pilot and main fieldwork, the fit between the classroom activities and Key Stage 2 subjects in the National Curriculum was emphasised. All the children involved in the fieldwork were at Key Stage 2 of the National Curriculum (Directgov, 2011). The classroom activities, which involved asking the children to think about their local environments, and the ways in which they travelled to school, were seen as a good fit with Geography and PSHE (Personal, Social and Health Education), both subject areas at Key Stage 2 of the National Curriculum (QCA Curriculum Division, 2008).

The aim of the pilot fieldwork was to trial instruments that had been designed both to build up a picture of children's travel and activities, and to provide some measure of their knowledge about the local environment.

5.4 Developing the questionnaire

During the piloting stage different versions of a questionnaire were trialled, the questionnaire was designed to provide details about the travel, and in later versions, the independent activities that children take part in.

An exploratory factor analysis of the version of the questionnaire used in the main study is shown below in Chapter 7.

5.5 Choosing the test of spatial knowledge

Figure 5-1: Mr Bentley helps pupils at St Joseph's Primary School to complete the fieldwork tasks

5.5.1 *Preselected landmark tests*

The pilot fieldwork also provided the opportunity to test a number of instruments designed to assess children's knowledge about the local environment. One of the original ideas was to assess the children's knowledge of their local environments by determining how accurately they could indicate the locations of pre-selected landmarks. One example of this type of method was the Direction Estimation Task (DET): in this task the children were asked to indicate which direction a series of landmarks lay from their current position in school.

Figure 5-1 shows a picture of one of the classes involved on the pilot work at St Joseph's Primary School.

Another test asked the children to study a map of the local area and try to identify which landmarks were being indicated by a series of numbered arrows. Figure 5-2 and Figure 5-3 show examples of the worksheets given to the children for the Landmark Recognition Task (LRT).

The children had to study the map sheets and decide which of the four landmarks shown on the response sheet was at the location. Three landmarks were taken from the local area, and one was taken from another area. Answers were given by ticking one of the boxes for each of the questions shown on the response sheet in Figure 5-3.

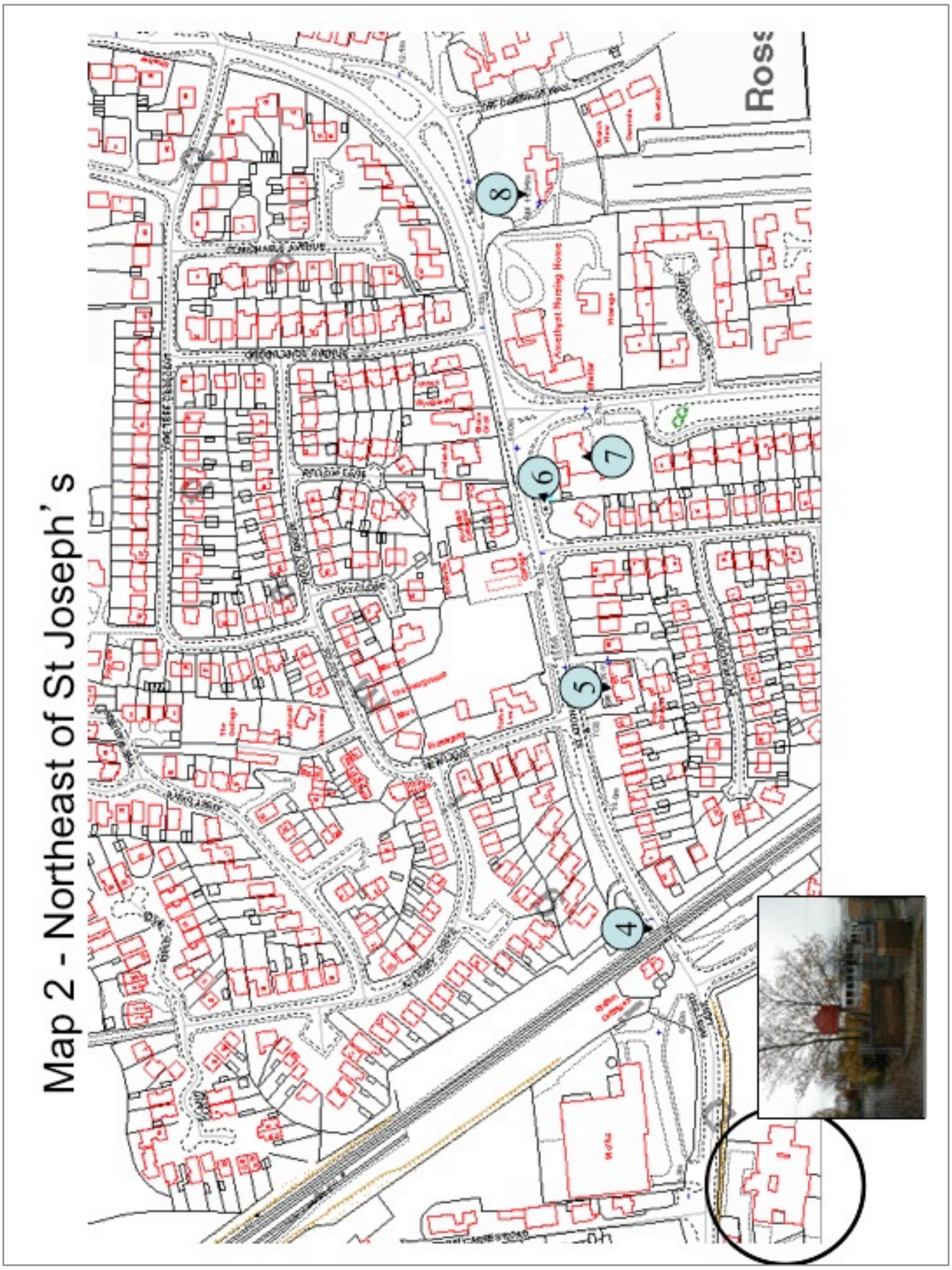


Figure 5-2: Part of the landmark identification task piloted with children in St Joseph's Primary School, Rossington

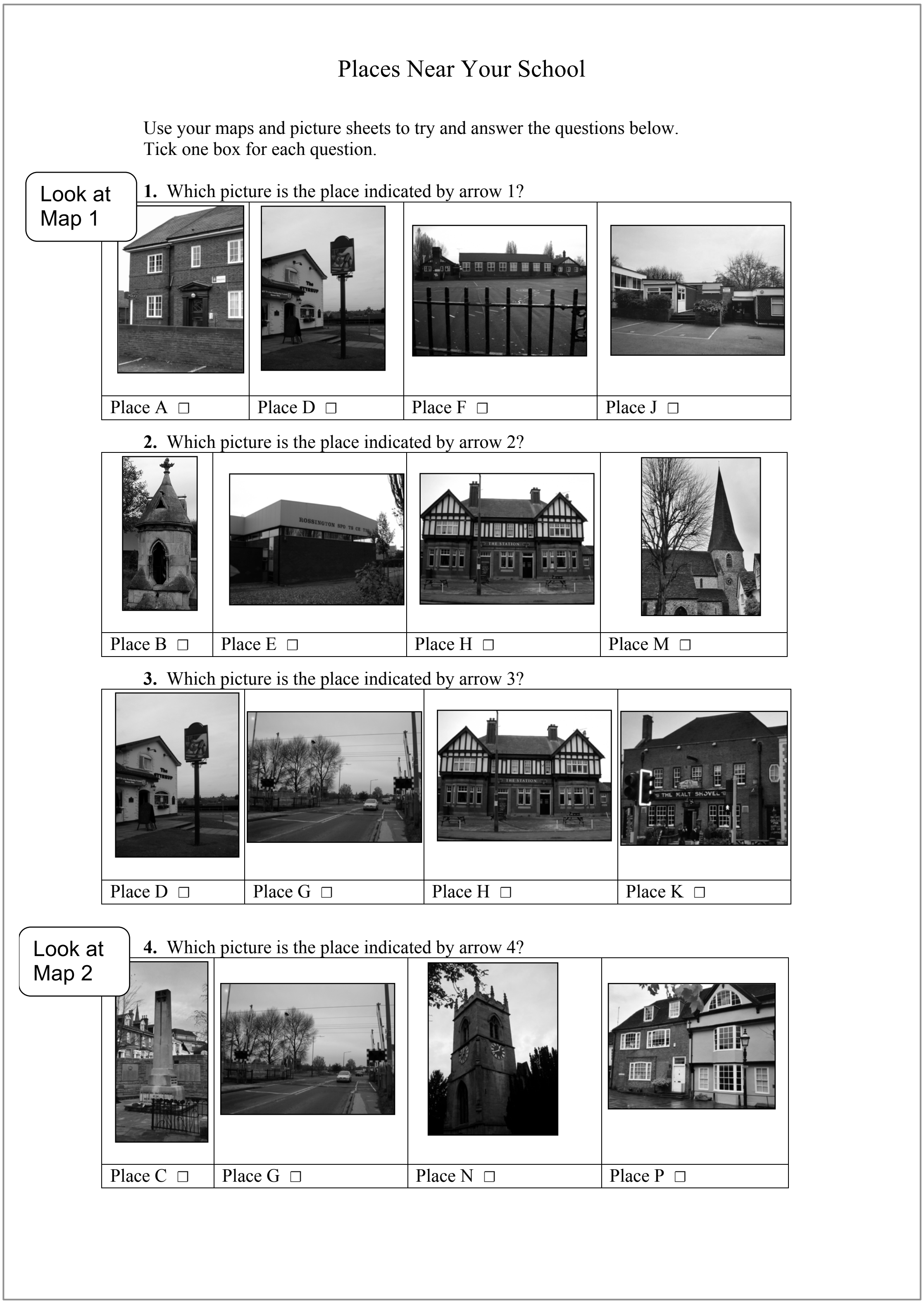


Figure 5-3: Response sheet for the Landmark Identification Task

There are common factors in all the pre-selected landmark methods, one is that the tasks rely on the children's recognition memory, rather than free recall, another is the need for a list of pre-selected landmarks. This style of task required the investigator to devise a list of important landmarks before the classroom exercise. Unfortunately it would have given away too much about the content of the upcoming tasks to consult with the schoolchildren about what should be on the list beforehand. During the piloting some attempt was made to get a list of important landmarks from the teachers of the classes, but on the whole the choices were made by the investigator walking around the area near the school noting down, and photographing, the kinds of features that he thought would catch a child’s eye.

Figure 5-4, shown below, gives some examples of the kind of features that were thought to be suitable landmarks. The choices were based on the distinctiveness of the features and the possibility that the children might spend some time in or around the potential landmark. The examples below include a church with a tall spire, a pub near the Rossington Primary School with a distinctive sign, a community centre in Broadfield and a dental surgery. All the examples given in Figure 5-4 are buildings, but other landmarks were included, such as a war memorial, level crossings and distinctive junctions or roundabouts.

Figure 5-4: Examples of the kind of landmark that were included in the pre-selected landmark task, all the landmarks above were used during the pilot phase

5.6 Results from piloting the Landmark Recognition Test

The results in this section are taken from the piloting session in Rossington. Two year groups, Year 4 and Year 6, completed the Landmark Recognition Task (LRT). Both year groups performed very well in the LRT: many children, especially those in the oldest age group, were able to correctly identify the indicated landmark. In Year 4, the younger group, 46% of children correctly identified the eight landmarks, in Year 6, the oldest group of children, this rose to 79%. Despite evidence of ceiling effects in Year 6 (which could have been addressed by using more landmarks from a larger area), differences between the age groups and boys and girls were apparent. There were also differences apparent between users of different modes.

Table 5-1 shows descriptive statistics for the scores from the Landmark Recognition Test in the pilot study, broken down by year group and the different modes used to get to school. The figures in Table 5-1 are for 67 of the 69 children, two children in Year 4 (one boy and one girl) travelled to school by bicycle. It can be seen that those who walk in each year group have the highest recognition scores, however the differences between modes was small and none of them were statistically significant.

Table 5-1: Mean recognition score by usual mode to school.

	Year 4	Year 6	Overall
Bus	6.3 (N = 4)	7.6 (N = 7)	7.0 (N = 11)
Car	6.5 (N = 21)	7.7 (N =16)	7.5 (N = 37)
Walk	6.8 (N = 6)	7.8 (N = 13)	7.1 (N = 19)
Overall	6.6 (N = 31)	7.7 (N = 36)	7.2 (N = 67)

There were far larger differences in the average recognition scores between the two year groups who took part in the pilot exercise, children in Year 6 had higher average scores than children in Year 4. Table 5-2 shows descriptive statistics for recognition scores for children in Year 4, children in Year 6, boys and girls.

Table 5-2: Recognition score by age and sex

	N	Mean	S.D.
Male	36	7.43	0.95
Female	33	6.84	1.94
Year 4	33	6.55	1.92
Year 6	36	7.74	0.57
Overall	69	7.15	1.52

Independent t-tests were used to compare the recognition scores between groups, where equal variances could not be assumed appropriate adjustments have been made. The t-tests show the difference between Year 4 and Year 6 children is significant ($t = 3.46$, $df = 37.38$, $p < 0.0005$, one-tailed, equal variances not assumed), but that the difference between boys and girls is not ($t = 1.59$, $df = 44.15$, $p = 0.064$, one-tailed, equal variances not assumed).

More details on the results from the pilot fieldwork, including an analysis of the results from the first set of area sketch maps can be found Paskins (2005).

Sketch mapping exercises were also trialled at the same time as pre-selected landmark tasks. An example of one of the completed sketch mapping worksheets is shown below in Figure 5-5. In the first instance (the pilot fieldwork in Broadfield) the sketch mapping worksheets only asked for a map that described the route taken on the journey to school that morning.

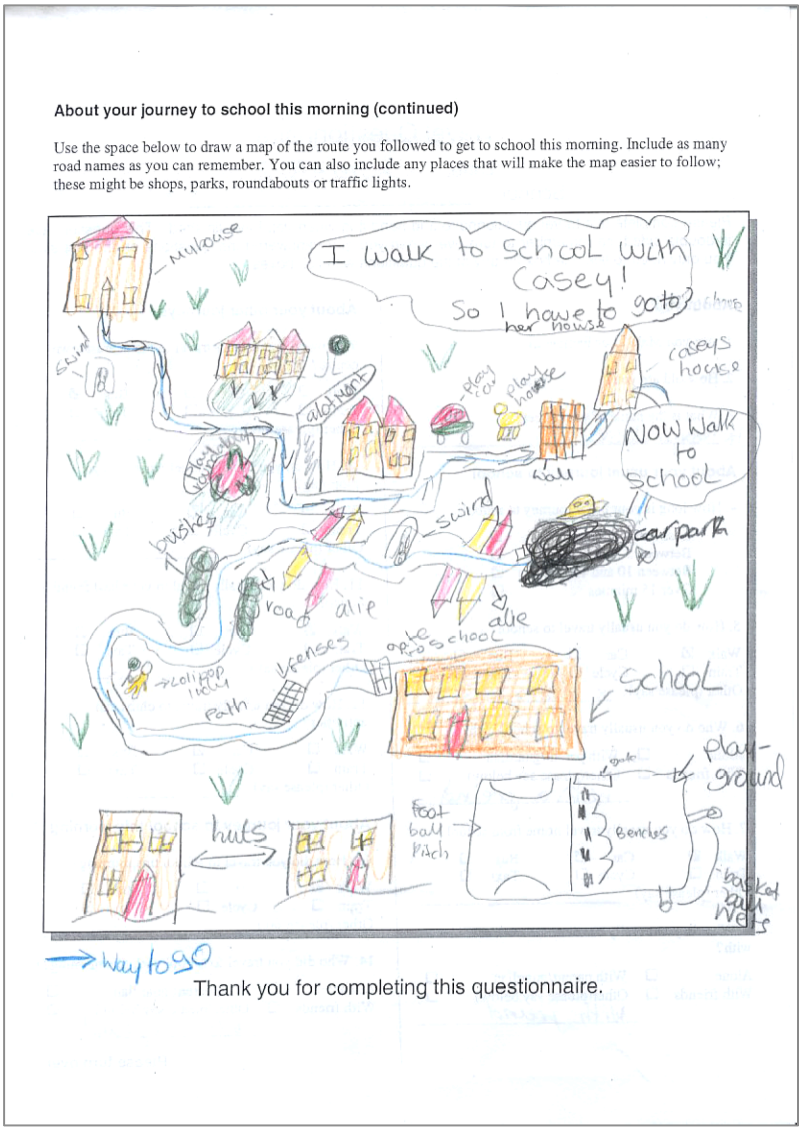


Figure 5-5: Second page of the Journey to School Worksheet used in the pilot work at the school in Broadfield near Crawley, West Sussex

Sketch mapping tasks are just one of a wide number of techniques that exist for assessing children's knowledge about large-scale environments. These can be broadly separated into those that test recall memory and those that test recognition memory

(Matthews, 1992). Each technique has its own strengths and weaknesses, and may involve the use of skills that mask a child’s true competence. For instance, children differ in both their drawing and writing abilities. In the case of sketch mapping tasks the ability of the child to draw and write will affect the ability of the researcher to accurately identify the landmark that the child intended to represent. The pilot study employed the sketch mapping tasks as a recall task, and as has already been stated, the pre-selected landmark task was a recognition task.

In contrast to the Pre-Selected Landmark tasks, which test recognition memory, the Sketch Mapping tasks relied on the children’s ability to recall information. The sketch mapping task utilised in this research have been classified as Recall-Survey for the area maps and Recall-Sequence for the route maps (Matthews, 1992). Both tasks ask the children to remember information in a largely unstructured fashion, at least as far as there is no structure imposed by the investigator. There is a degree of structure in asking the children to recall information along the route between their homes and their school, but this is a different sequence for each child, and the children were free to draw the route in any sequence they chose, they could, for instance, add extra landmarks along the route, and make any other changes within the time available. In contrast to this, the pre-selected landmark tasks, particularly the DET, where the landmarks were addressed in the sequence read out by the investigator, imposed a clear structure on the children.

The recall tasks, the sketch mapping exercises, involved drawing a map and labelling its elements. This relies, in part, on skills that are unrelated to the child’s knowledge about the environment. The recognition task did not rely on a child’s ability to write or draw, it did however rely on the child’s ability to read a map.

For the second school, St Joseph’s in Rossington, the sketch-mapping task was extended to include a worksheet that asked for a local area map, centred on the school. This was also a test of recall memory, but this time an area recall task, rather than the route recall task presented by the Journey to School worksheet. In practice, however, it was not unusual for children to extend the area around the route, and these ‘fat routes’ must also involve a degree of area recall. Figure 5-6 and 5-7, below, show examples of area maps drawn by pupils in Year 4 (Figure 5-6) and Year 6 (Figure 5-7).

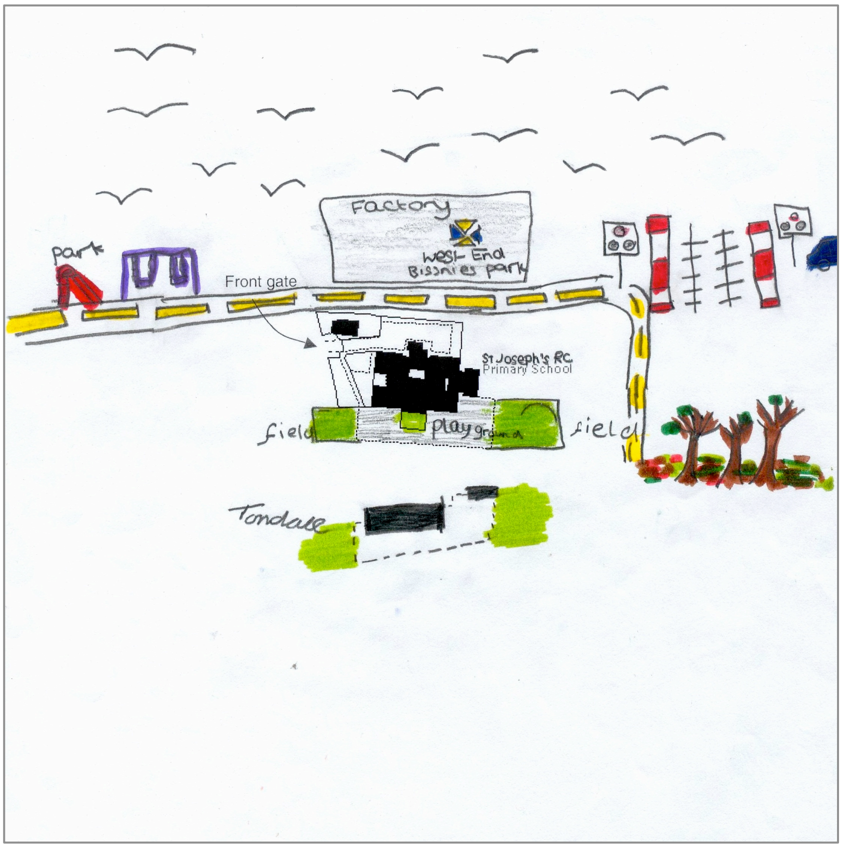


Figure 5-6: Area sketch map drawn by a child in Year 4 at St Joseph's school

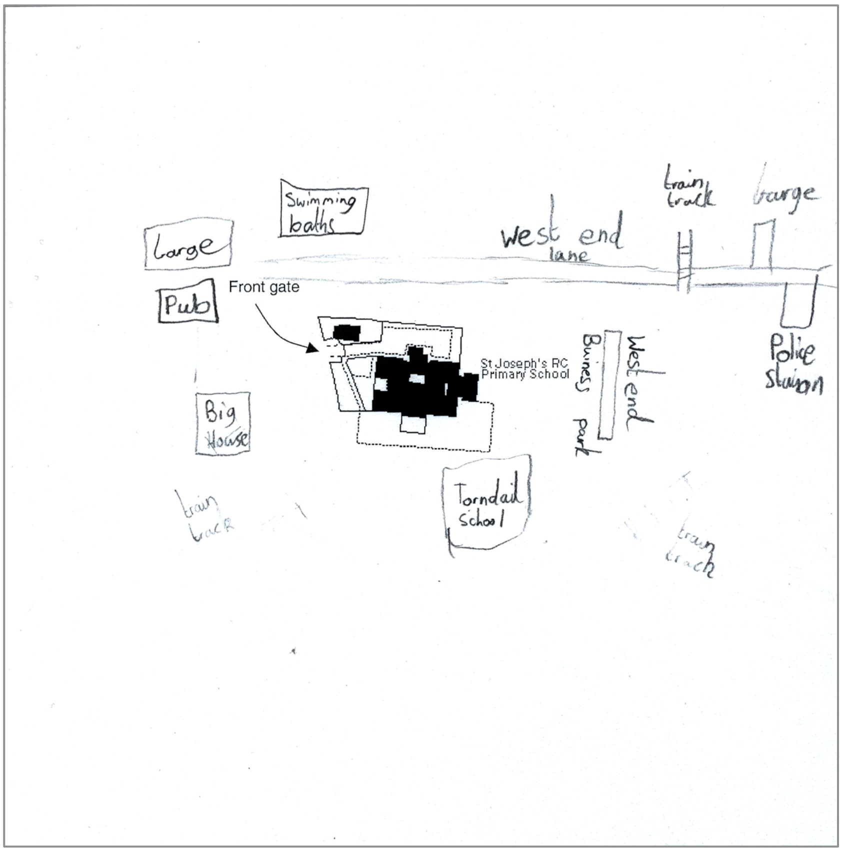


Figure 5-7: Area sketch map drawn by a child in Year 6 at St Joseph's school

When all the schoolchildren were considered together the results from the sketch mapping tasks provided a much richer set of landmarks than it would have been possible for the investigator to compile. The tasks provide a fuller and fairer representation of the children's knowledge about the local environment. For instance, in the procedure for determining the accuracy of the children's sketch maps, which will be discussed later in this section, the scores for accuracy of landmark placement are based on the landmarks that the children recall, rather than a list imposed upon them.

The different methodologies, tests of recognition versus tests of recall, introduce different methodological considerations. For example, asking a child to draw a map relies on their ability to draw as well as their ability to recall information about the local environment. It was recognised that this would have an effect on the ratings given to the child's style of representation, most likely causing a child's spatial competence to be underestimated. However, it was felt that it would have less impact on a child's ability to represent the relative positions of map elements, and that giving the child a free choice in what can be included, as is the case in all of the sketch mapping tasks, would lead to a fairer assessment of the child's spatial knowledge. The previously mentioned attributes of the children's sketch maps, style and accuracy are two of the different bases for analysis. The different ways in which the maps can be analysed will be discussed in more detail later in this thesis (Chapters 6 and 10).

Another disadvantage of the sketch mapping tasks (this time for the investigator) is the difficulty involved in their interpretation, or at least the amount of processing that is required before any kind of measure of accuracy can be distilled from the drawing. Measures of detail and style, or cartographic competence, can be obtained in a straightforward manner from the sketch maps. Measures of accuracy, however, relied on a comparison between the sketched map and an Ordnance Survey map of the same area, which was a time consuming process. While there may be some work involved in calculating the final result for one of the pre-selected landmark tasks (comparing angles or marking response sheets, for example), the processing required to produce a result for further analysis was minimal. Each of the pre-selected landmark tasks provided a single numerical outcome for a child: in the case of the Direction Estimation Task this was a deviation from the actual angle of the landmark, in the case of the Landmark Identification Task it was a total of correct answers. The time taken by the investigator in selecting the landmarks and preparing the materials for each school, or class, was very much less than the amount of time taken to process the children's sketch maps.

The most labour intensive task, identifying the landmarks represented in the children's maps and matching them to their real-world counterparts, which was required to study the accuracy of element placement, will be discussed in detail below.

The children who took part in the main fieldwork were also involved in the CAPABLE research project. The programme of fieldwork for the CAPABLE project was already quite time consuming, for instance, children involved in the GPS and Physical Activity Monitoring study were required to involved in some kind of project related activity on each day of the week: children were weighed and measured and given the equipment on a Wednesday, they then wore the equipment until the following Monday, and on Tuesday took part in a feedback session. To avoid participation fatigue, and to minimise the disruption to the children's schoolwork, and keep the cooperation of the teachers it was decided not to employ both the pre-selected landmark tasks and the Sketch Mapping Tasks.

Overall it was felt that the freedom afforded to the children by the sketch mapping tasks was more important than the ease of processing the results.

5.7 GPS monitoring for school travel

Another important requirement for this research was the ability to gather data about the children's travel behaviour. One way in which this was done was through the use of the CATS travel and activity diary (see Section 4.8). GPS monitoring was used in conjunction with the diary, and the results were analysed to see if they could provide a detailed picture of the children's behaviour. Location was monitored using a Garmin Foretrex 201 GPS unit. More detail about the GPS units considered for this study, including some discussion of the compromises involved in selecting the GPS unit, can be found in Appendix 3.

5.7.1 GPS coverage for the journey to school

The journey that relates most closely to the information recorded in the children's sketch maps is the journey to school. The GPS data captured on weekday mornings, for all the children at the Cheshunt schools, is shown below in Figure 5-8. Each point in Figure 5-8 below indicates a position fix recorded by a child's GPS unit.

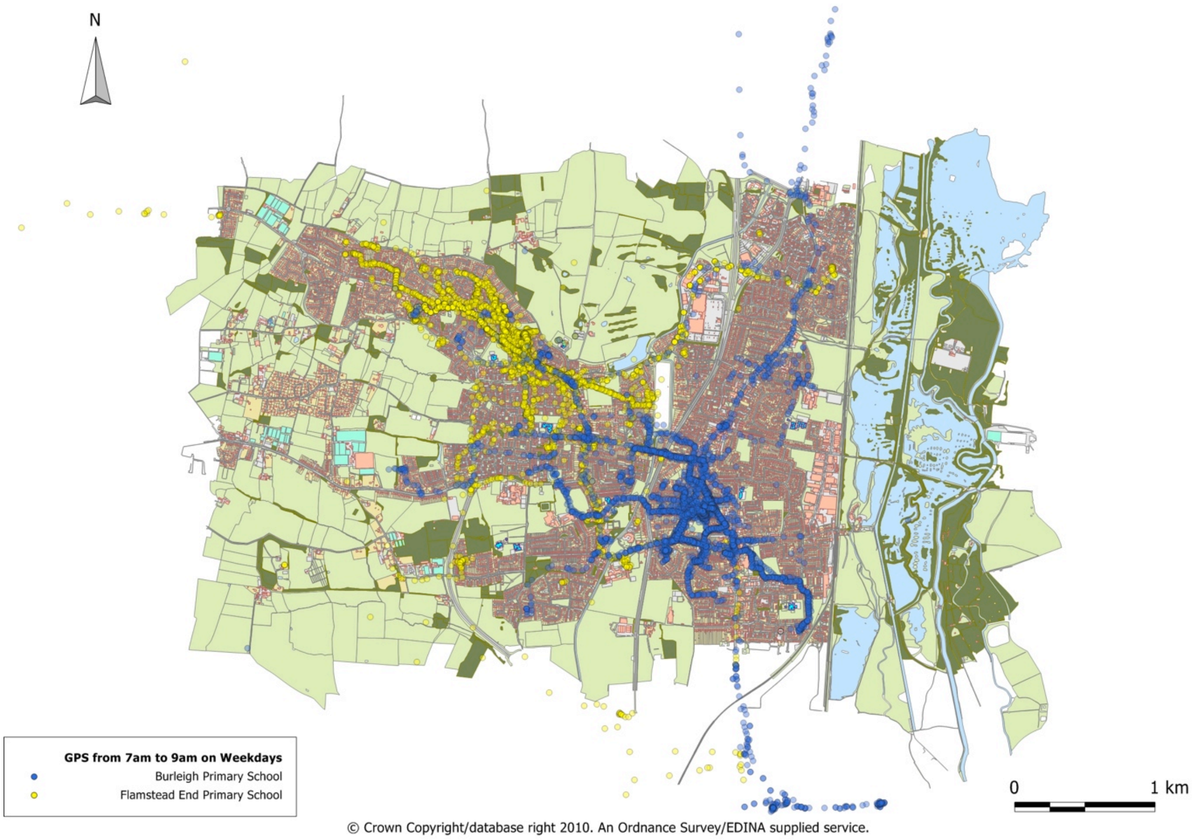


Figure 5-8: GPS points recorded by children at the two Cheshunt schools

The blue points in Figure 5-8 above are GPS points for the children who attended Burleigh Primary School, the yellow points are for children who attended Flamstead End Primary School.

5.8 GPS limitations

Accuracy in GPS devices is highly dependent on both the design of the unit and the environment that the unit is used in. GPS position fixes rely on weak radio signals beamed from a constellation of orbiting atomic clocks, this 'invisible infrastructure' (McNeff, 2002) allows both accurate positioning and time synchronisation.

This low powered signal is easily attenuated, especially during the final part of the journey, as it encounters buildings and trees. The majority of GPS devices will not work inside a building (Dempster & Dedes, 2005), and most will have their accuracy effected by anything, including foliage, that obstructs the aerial's 'view' of the sky.

Because the children were using the GPS devices in an urban environment as part of their day-to-day activities, it was often the case that their GPS devices would lose the signal as they entered buildings or vehicles. There is a delay involved with reacquiring the satellite signals when the child's devices can 'see' the sky again. For the device used in the study the time required to acquire a signal ranges between 15-45 seconds in normal operation, in some situations it can take up to 30 minutes to make the first position fix (Garmin, 2004).

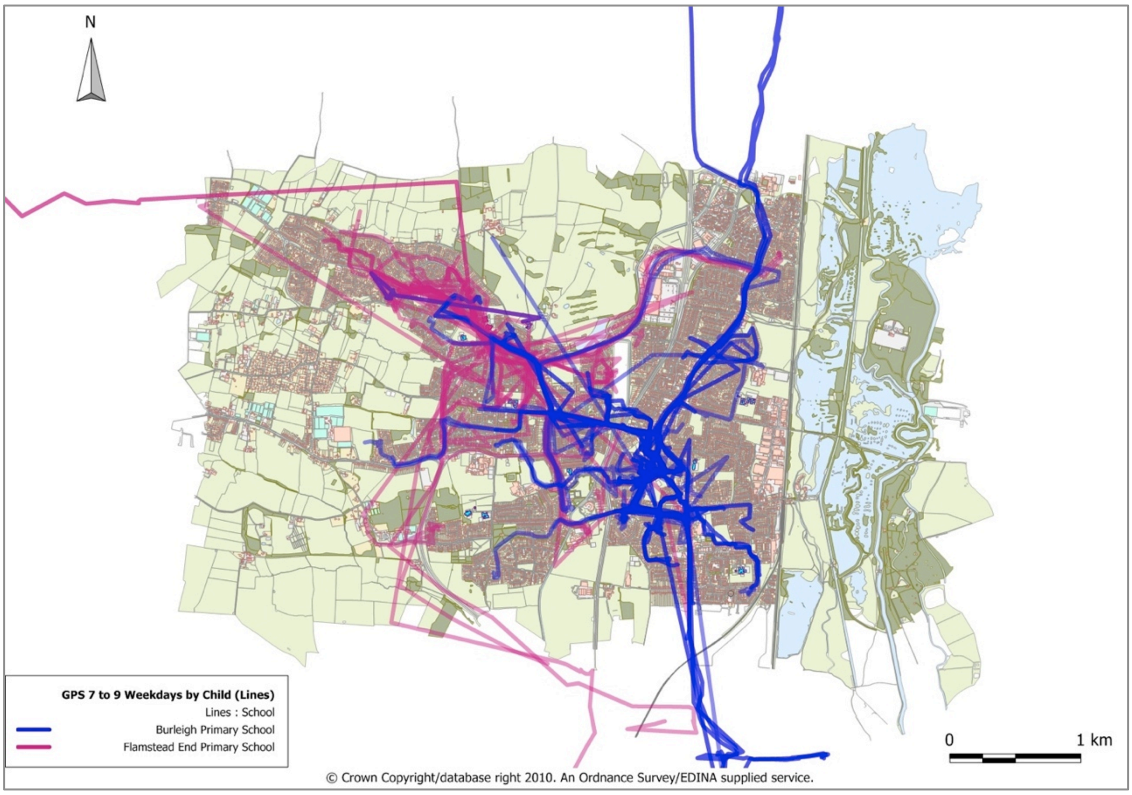


Figure 5-9: All GPS traces for the journey to school

5.9 Reasons for rejecting GPS for the main study

The majority of good, usable GPS traces came from children who travelled by car. This is probably because the GPS unit had more time to acquire and track the satellites required to determine position information. The short duration of walking trips, combined with the amount of time it could take for the GPS receiver to get a position fix led to large parts of the GPS trace for short walking journeys being lost.

Despite the high density of traces that are apparent in Figure 5-9, there are not enough available to make a sensible comparison between different modes of travel. Most of the clearest and most useful traces belong to children who were passengers in cars, and there are only a few walking traces, and even fewer that can be matched to a route sketch map with useful, identifiable, features.

Regrettably, it has been decided to leave the comparison between GPS and route sketch maps as a suggestion for future work. The potential of the technique, especially given the advances in technology that have occurred in the intervening years, are clear.

Figure 5-10 and Figure 5-11 show one of the best examples of a fit between a route sketch map and a GPS trace. In this example, not only did the participant provide a clear map with unambiguous landmark information, they also managed to record three days of GPS information that covered the journey to school.

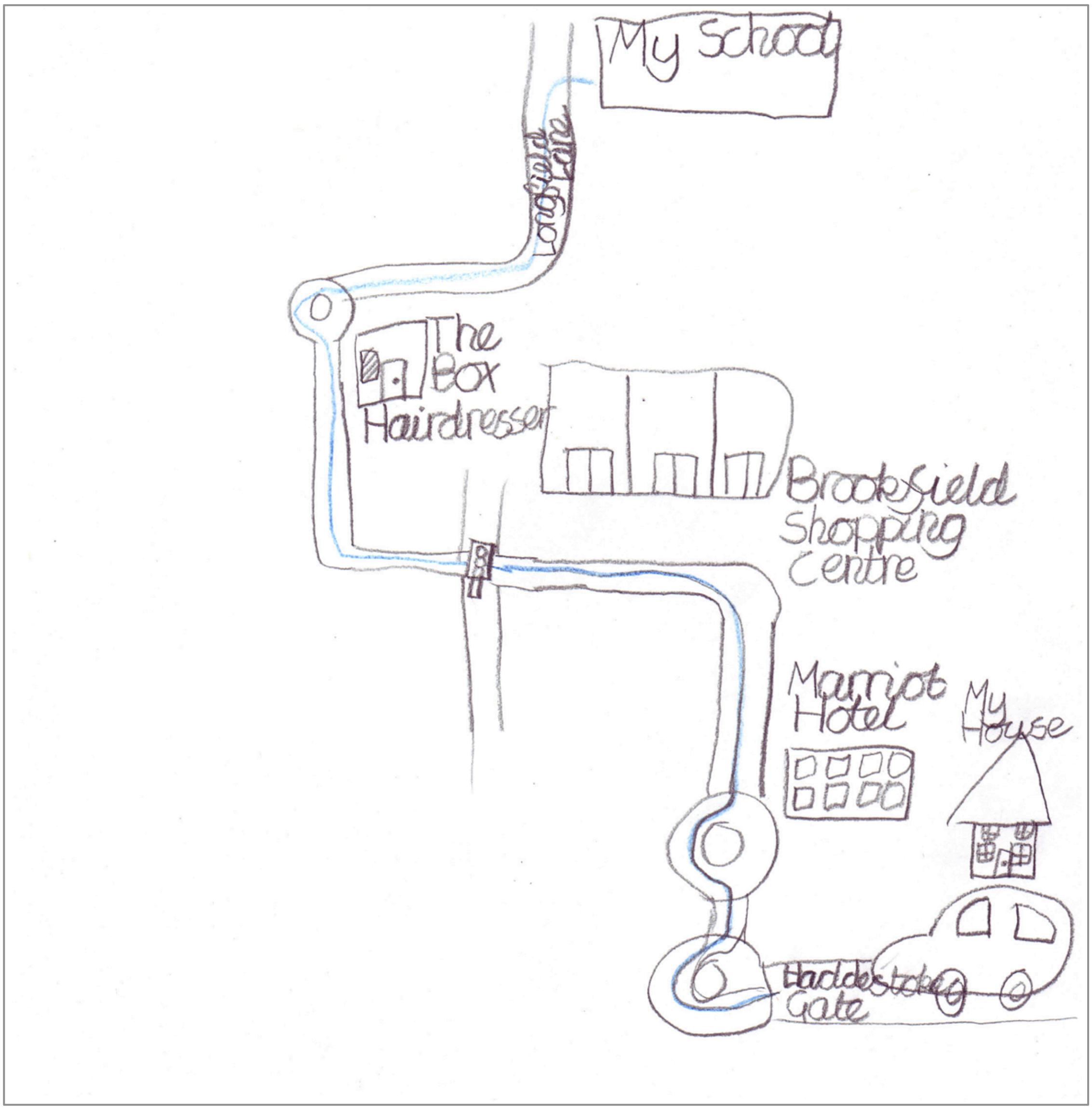


Figure 5-10: An example of a route map that has a very close fit with the GPS data (FE5-051)

Figure 5-11 on the following page shows how the route sketch map for FE5-051 can be matched to the GPS record for the journey to school. A number of key points can be easily matched between the sketch map and the real world map. It can be seen that the elements occur in the same order in both the sketch map and the real world trace.

Unfortunately, the example shown in Figure 5-11 is a rare example. Many of the maps simply do not include enough unambiguous detail to begin match them with the GPS traces. Another problem is that many of the shorter, often walking, journeys have not been captured, or at least, the majority of the journey is missing.

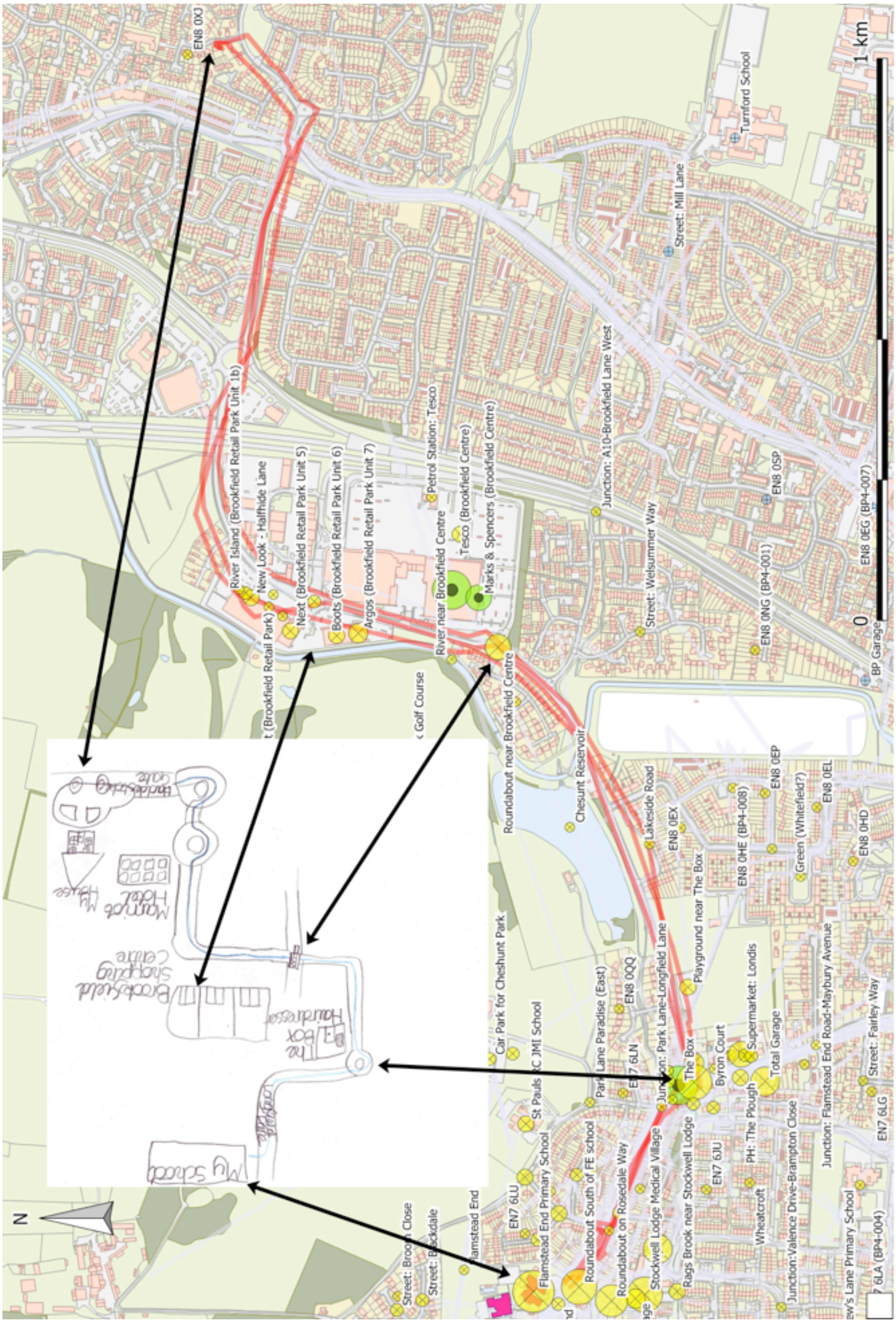


Figure 5-11: Comparing a GPS trace with a sketched route map

5.10 Chapter summary

This chapter covered the experience of piloting fieldwork instruments. The research question required measures of children's travel and other activities, in addition to measures of the quality of the children's cognitive spatial maps.

The research relies on the ability to find an instrument that can provide a measure of the quality of children's cognitive spatial representations. A number of alternatives were considered and trialled, including hidden landmark tests, and tests of landmark recognition. The tests that involved pre-selected landmarks involved some preparation before the fieldwork, mainly choosing suitable landmarks, but yielded results with very little processing.

Amongst the other instruments trialled were two sketch mapping tasks, one for the journey to school and one for the area around the school. These tasks involved only a little work to customise the materials for each school, and had the advantage that the children had the freedom include any landmarks that they wanted to. These maps gave a richer picture of the children's environmental knowledge than could be gained by asking them to work with a list of landmarks selected by the investigator. It was decided that the technique was worth the problems presented by analysis, which will be covered in the next chapter.

Initially the children's travel was investigated with simple questions covering mode of travel to school on the day that the sketch maps were made. GPS monitoring offered the possibility to record information about children's travel, with the advantages of accurate timing and position information. One of the initial aims of the research was to make detailed comparisons between the maps of those who walked to school and those who travelled by car. Unfortunately, even though car use was reasonably well represented, walking was massively underrepresented in the sample. Walking traces were often either very short or non-existent.

There does, however, seem to be a great deal of promise in the link between GPS location data and a child's recollection of their travelled route, and with improved GPS tracking it may become possible to investigate it.

6 Processing the children's sketch maps

Children's sketch maps were used as the main measure of the quality of the children's cognitive representations of the local environment. The sketch maps were analysed in a number of different ways. Area Sketch Maps (ASM) and Route Sketch Maps (RSM) were used for different analyses. Some of the types of analysis required the sketch maps to have been processed to render the contents of the maps into an analysable form. The children's maps differ from each other in a number of ways, some of these are differences involving the individual elements that make up the map, such as the level of detail present in the map, and the accuracy of the placement of those elements. There are also global differences between the maps, these difference can be captured by overall measures of representational style used for the sketch map elements, and classifications for the type of network that the child used to connect the sketch map elements.

It is the analysis of the first set of differences, those that deal with the individual elements, that required the most processing to be carried out on the sketch maps. The global measures, overall style and network type, involve the whole map and require less intensive processing.

The following analyses were made for the Route Sketch Maps:

- Categorisation by representational style
- Categorisation by the type of network that connects the elements, if present
- Comparison with GPS traces in the cases where a child has recorded data covering the journey to school

The following analyses were made for the Area Sketch Maps:

- Categorisation by representational style
- Categorisation by the type of network that connects the elements, if present
- Analysed for the level of detail that they contain
- Analysed for the accuracy of the element placement

Other differences are also apparent, but will not be considered here. There are many differences at the whole map level that could be the basis for analysis. For instance, it was decided not to consider the use of the space available on the paper, Figures 6-1 and

6-2 below shows two area maps where the children have used the space available on the worksheet in different ways.

Figure 6-1: Area sketch that uses only part of the available space (6NN_Area_19)

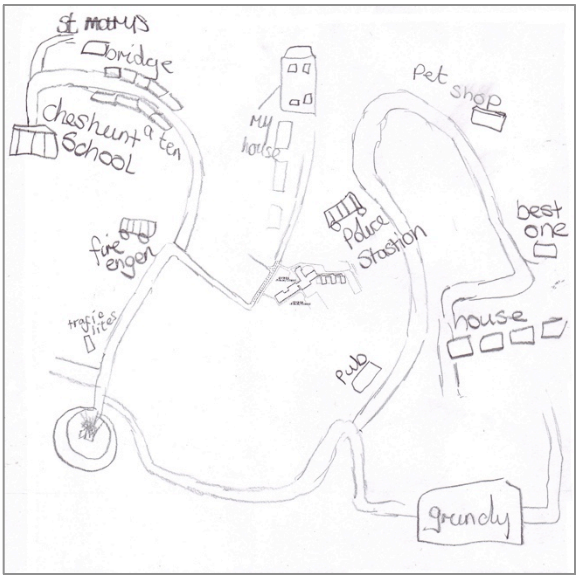


Figure 6-2: Area sketch map that makes use of most of the space available on the worksheet (6KM_Area_17)

In the example on the left, only the bottom left hand side of the space has been used, while example on the right shows a map that makes use of the whole space available on the paper.

Another two potentially interesting differences that are apparent from the maps, but which will not be analysed in detail here, are the kinds of non-landmark information included (vehicles, people, animals, etc.), the relative size of the sketch map elements within a map, and the differences in representational style used for elements in a given map (as opposed to the overall representational style).

6.1.1 Analysing the Area Sketch Maps for detail

One of the most straightforward properties of the maps to analyse, and the one that requires probably the least subjective assessment, is the detail present in the map. The simplest way to do this would be to count up all the discrete elements that the child has included in his or her sketch map. However, it turns out that this assessment is not as straightforward as it might first appear. Some thought needs to be given to what is included as a sketch map element. The main limitation imposed on the detail calculation was that a sketch map element should be linked with a real world counterpart with a real world position.

The process for linking the sketch map elements with their real world counterparts is covered in more detail in the next section, where the processing and analysis required to find a measure of accuracy is described.

6.1.2 Analysing the Area Sketch Maps for accuracy

It was decided that to aid the analysis of detail and accuracy the elements represented in the child's sketch map should be represented as a configuration of points. A requirement for inclusion in this configuration was that all of the points that made up the configuration should represent an object that has a known location in the real world.

Figures 6-3 and 6-4, below, show an area sketch map and how that map is represented by a two-dimensional configuration of points. Almost all of the elements in the children's maps are represented as areas; for instance, the small pictures of buildings in the sketch map below have an area. The two-dimensional representation uses the centre point of that area to represent the element.

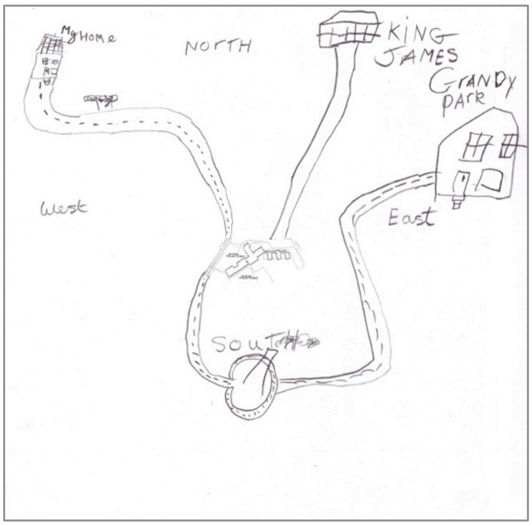


Figure 6-3: Area Sketch map from a child at Burleigh Primary School (BP4-042)

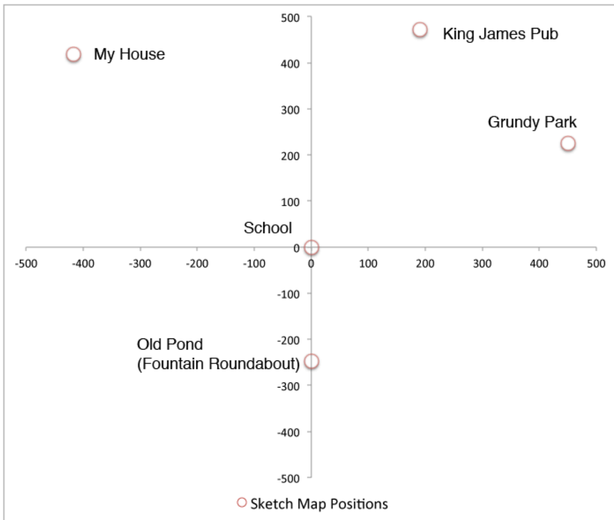


Figure 6-4: The configuration of points produced from the area sketch map on the left

6.1.3 Map qualities lost when converting to a configuration of points

It is recognised that there is a wealth of information in the way that the different sketch map element are drawn. One example of this is the way in which different representational styles are mixed within a single child's sketch map. Children who are classified as drawing maps in the plan-pictorial style (see Chapter 10) are mixing highly map like elements, for instance top-down views of buildings, with what are essentially pictures, representations of the element as it might be seen from the child's street-level point of view. While an analysis of which elements are represented in which ways would be interesting, and potentially illuminating, these within-child, or within-map stylistic differences have been sacrificed to render the maps into a manageable dataset.

In addition to creating a very large dataset, the time required to convert the maps into two-dimensional dataset already represents a significant amount of the time given to the analysis of the data. Adding a further stage to classify the individual elements by style would have been very time-consuming, but it is not ruled out as an exercise for future analysis.

6.1.4 Linking sketched positions with real world positions

Figure 6-5 shows the link between the positions as sketched and the real world positions, it can be seen that each of the sketched elements is linked to an object with a real-world position. It can be seen from the figure below that the sketched position of the school, and the real world position of the school, share the same point (0,0). The worksheets for the area sketch mapping exercise included a picture of the school in the centre of the space provided to draw the map, and all the sketched area maps are centred on the child's school.

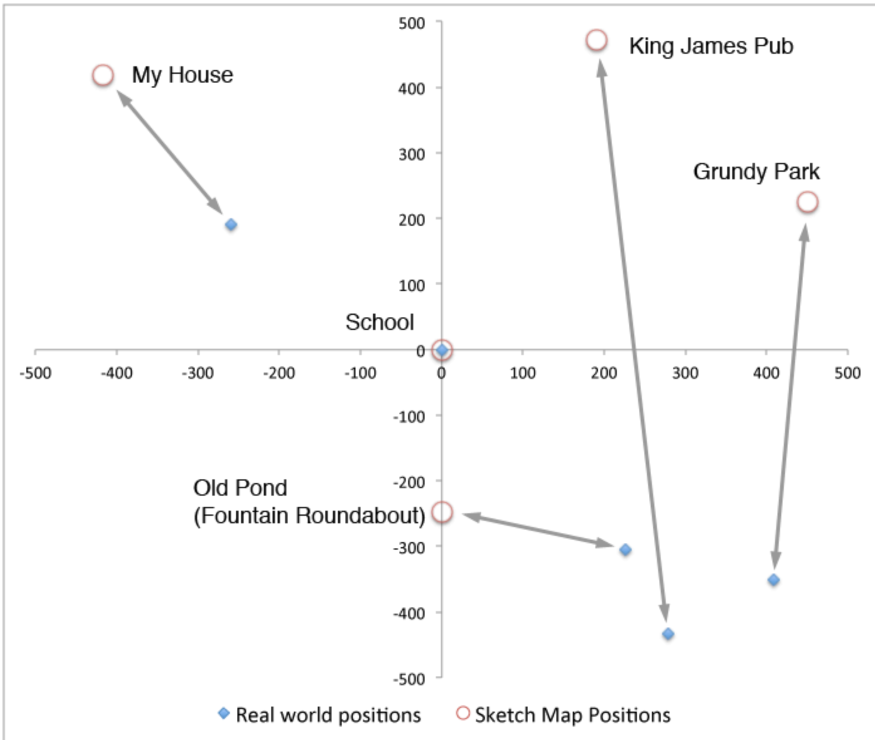


Figure 6-5: Graph showing the position of sketched and real world positions for one child's (BP4-042) map

Representing area maps as a set of two-dimensional points works well for features such as buildings and other landmarks that can be thought of as occupying a single location, but it works less well for any feature with any significant extension, the most obvious examples are roads and rivers. In practice roads and rivers were counted by their intersections with other elements, such as the road bridge over river shown below in Figure 6-6.

Figure 6-6: Elements with extension, such as rivers and roads, are difficult to represent when the maps are converted into a configuration of points

Because of the importance of intersections, roundabouts and junctions became important datapoints in the analysis of the children’s sketch maps. In many cases junctions and roundabout could only be identified unambiguously when the annotations were included for the roads that made up the junction, or the roundabout itself is named.

There are some drawbacks to the need for unambiguously identifiable landmarks. There are, for example, a number of types of feature that it is perfectly reasonable for a child to include, but that are excluded from the analysis because of the difficulty in making an unambiguous link with a real world counterpart. It is difficult, for example, to identify individual houses and natural features, such as plants, trees and rivers.

A decision was made only to include sketch map elements that could be matched to a real world counterpart, referred to as “unambiguously identifiable sketch map elements”. The following section gives more detail about the process of converting the children’s maps into two-dimensional configurations.

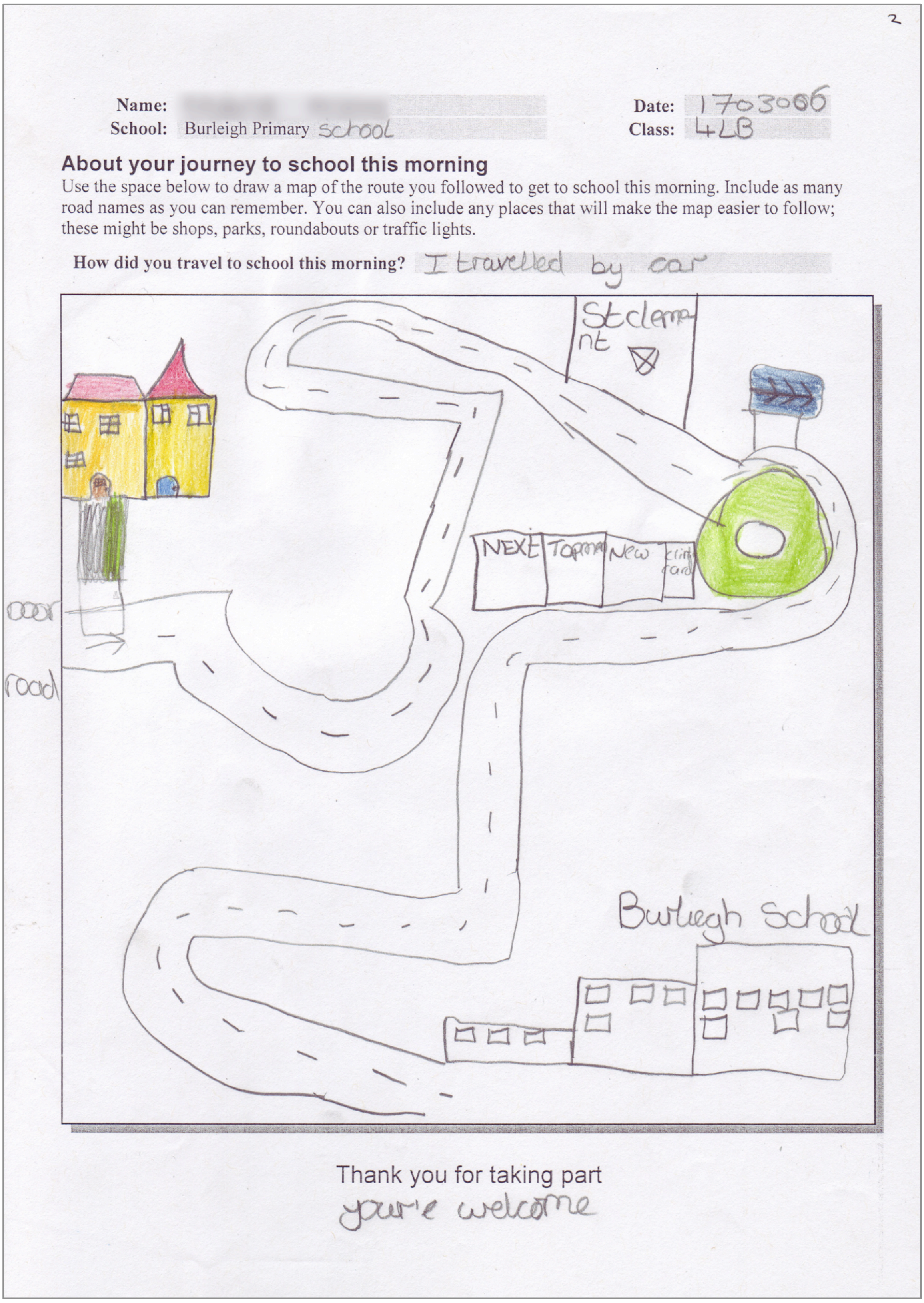
6.2 Stages for area sketch map analysis

Stage		Detail
1	**Initial Scan**	The worksheets were scanned using a flatbed scanner. The A4 sheets were scanned at a resolution of 300 dpi to produce 2480 x 3508 pixel images (over 8 megapixels).
2	**Crop and clean up the image**	The scans were cropped in an image editor to remove personally identifying information. The brightness and contrast of the image was also adjusted to improve the clarity of the maps.
3	**Calculate a central representative point**	The information tool in the graphics editor was used to find the coordinates for two opposite corners on each sketch map element. Theses coordinates were then used to calculate a single representative point for the element.
4	**Record details for each sketch map element**	A name was given to each sketch map element, this was based on the name given by the child The pixel coordinates were also recorded in the spreadsheet and the coordinates for the centre point of element were calculated.
5	**Finding the sketch map elements in the real world**	MasterMap, detailed Ordnance Survey maps data and Streetview, part of Google Maps, were used to identify the real world position of the element.
6	**Record the details for the positions of the real world objects**	The latitude and longitude of the central point of objects in the detailed map view were recorded as Latitudes and Longitudes (in metres).

The following sections give more detail, and illustrate the stages described above.

6.2.1 Stage 1: Initial scan

The worksheets containing the children's maps were scanned using a flatbed scanner. The A4 sheets were scanned at a resolution of 300 dpi to produce highly detailed digital images (2480 x 3508 pixel images, around 8.7 megapixels). An example of one of the original scans is shown below in Figure 6-7. The name of the child has been blurred and the map has been resized for printing. The initial scan file was saved as a jpeg file with a filename that included the child's class, the kind of map (area or route), and a number. The number was unique to that class/map type combination. Using this naming scheme the map shown below in Figure 6-7 was named 4LB_Route_02. It can be seen that, as well as some personally identifying information, the map also includes the standard instructions and blank space. It was decided that for analysis and presentation the child's sketch map should be extracted from the worksheet.


2

Name: [redacted] Date: 17030006
School: Burleigh Primary school Class: 4LB

About your journey to school this morning

Use the space below to draw a map of the route you followed to get to school this morning. Include as many road names as you can remember. You can also include any places that will make the map easier to follow; these might be shops, parks, roundabouts or traffic lights.

How did you travel to school this morning? I travelled by car

Thank you for taking part
your'e welcome

Figure 6-7: Initial scanned image of a worksheet (4LB_Route_02)

6.2.2 Stage 2: Crop and clean up the image

To leave only the child’s sketch map, the scanned image was edited to remove the instructions and all of the details they had completed. The colour and contrast of the scans were also improved at this point, and any misalignment of the initial scan was also corrected by rotating the image. The results of the crop and adjustments to Figure 6-7 are shown in Figure 6-8 below. All of the sketch maps in the study were adjusted in this way, and can be seen in Appendices 7, 8 and 9: Each of the these three different appendices includes sketch maps (area and route) for all the children whose area sketch maps had been classified as pictorial, plan-pictorial and plan respectively (see Section 8 for a description of process of classification).

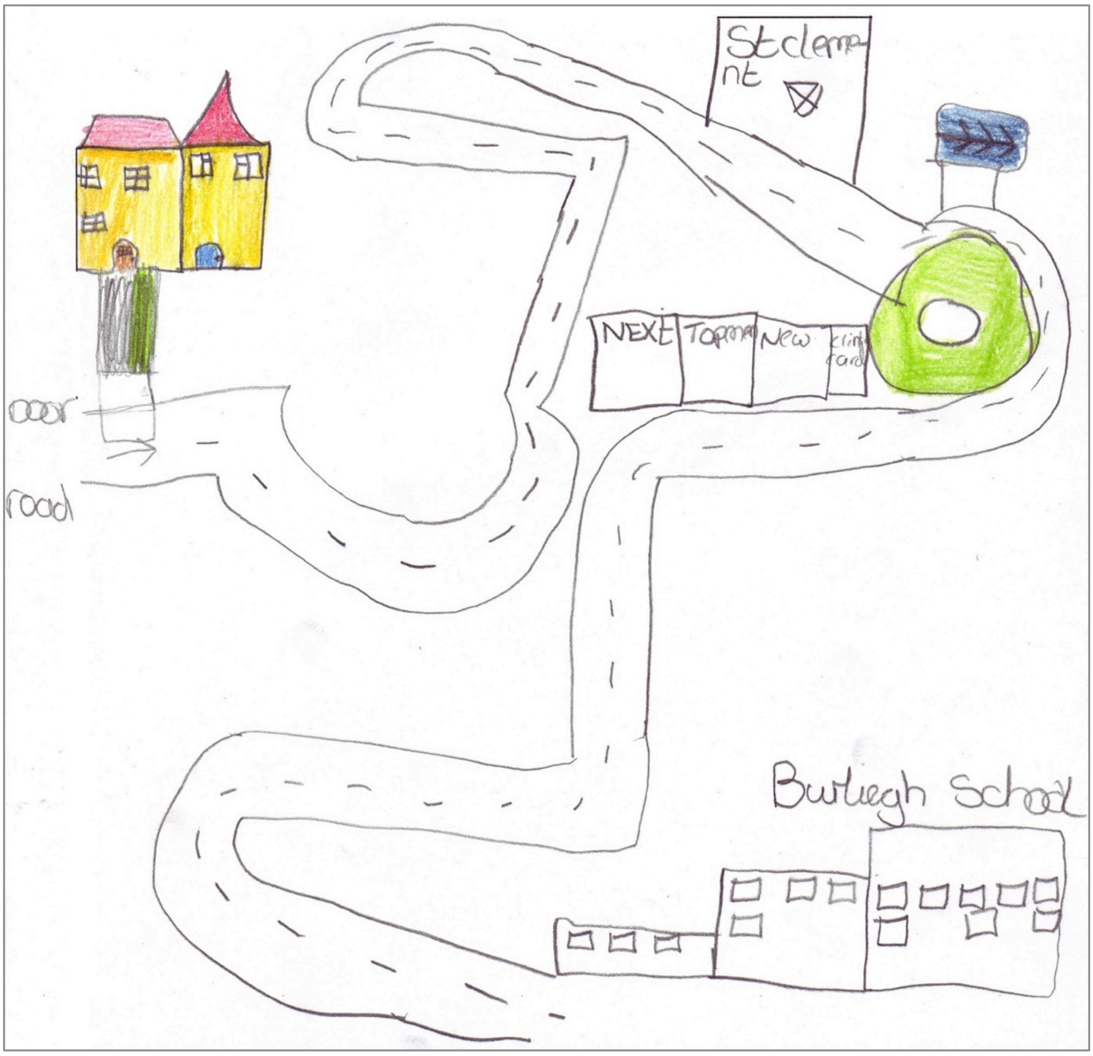


Figure 6-8: Sketch map worksheet after cropping and adjustments

A reference list was created that linked the individual map reference (4LB_Route_02 for the map above) to the child’s unique reference number, BP4-004, in this case. The child's unique reference is made up of the school, followed by the year group and a final number unique to that school/year group combination.

6.2.3 Stage 3: Find the centre of sketch map elements

As further analysis required each of the area sketch maps to be converted into a series of points, it was necessary to find a representative point for each of the elements. An image editor was used to identify the position of points in the scanned image. The image editor used in this case was Adobe Photoshop CS3 (Adobe Systems Incorporated © 1990–2007), Figure 6-9 (shown below), shows the "Info" tool in action. In Figure 6-9 the Info tool is being used to find the position of the top left-hand corner of the scanned image of Flamstead End Primary School.

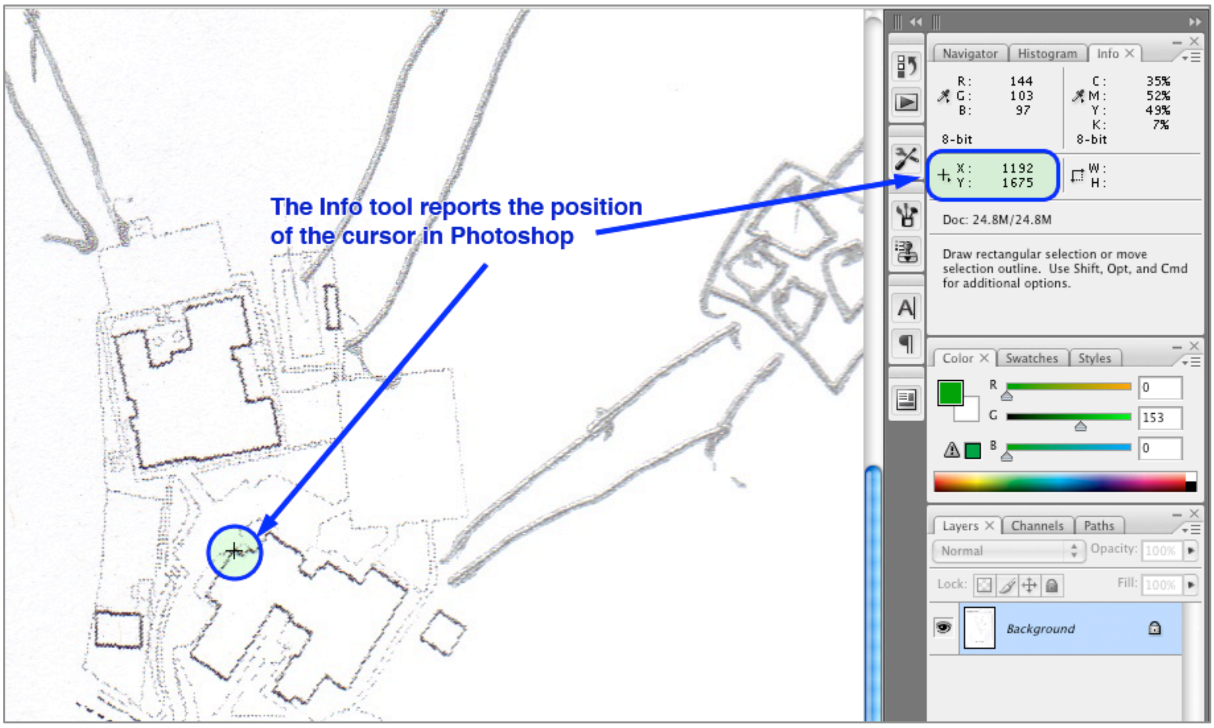


Figure 6-9: Using the "Info" tool in Adobe Photoshop to find the positions of points in the scanned image

The position of the centre of all the potentially identifiable elements, in pixels, was calculated using the coordinates for the top left and the bottom right corners of the element. Some of the elements in the sketch maps are far more pictorial in nature, featuring roofs, fountains and, in the case of some elements, like the fire station, towers. It was decided to calculate the centre of the main body of the each element, and to exclude extra features. Figure 6-10 shows the points used to calculate the centre of the element 'chemist', the roof drawn for the building has been ignored.

Figure 6-10: Determining the centre of a sketch map element, roofs of pictorial elements were not counted

Many of the more generic elements were excluded at this stage, shops and houses that did not have any further identifying details, for instance. In many cases it did not appear possible to unambiguously identify some elements, trees or areas of grass, unless they were named, or there was a nearby element that helped identification.

6.2.4 Stage 4: Record details for each sketch map element

A record was added to a spreadsheet for each potentially identifiable sketch map element. Each record included two coordinate pairs, describing opposite corners of an element, and a name for the element. The name for the element was either the name given by the child (or at least the closest guess that the investigator could make about what the child meant to write), or a description of the element based on its appearance, and its proximity to other elements. The vast majority of maps included some kind of annotation for the elements.

In Figure 6-11 it can be seen that the elements were named either for what was simply recorded in the map: “Tesco”, “Fair Fields”, “The Box” and “Alleyway”; or with some extra detail based on the proximity of other elements: “Field near Fairfields” and “Playground near Fairfields”. The ‘Element name’ heading, shown in the spreadsheet in Figure 6-11, also includes a progress indicator: ‘NM’ gives the percentage of unmatched elements in the list, ‘Blank’ the percentage of rows missing an element name and ‘WTM’ (waiting to match) gives the percentage of elements waiting for an attempt to made to match them.

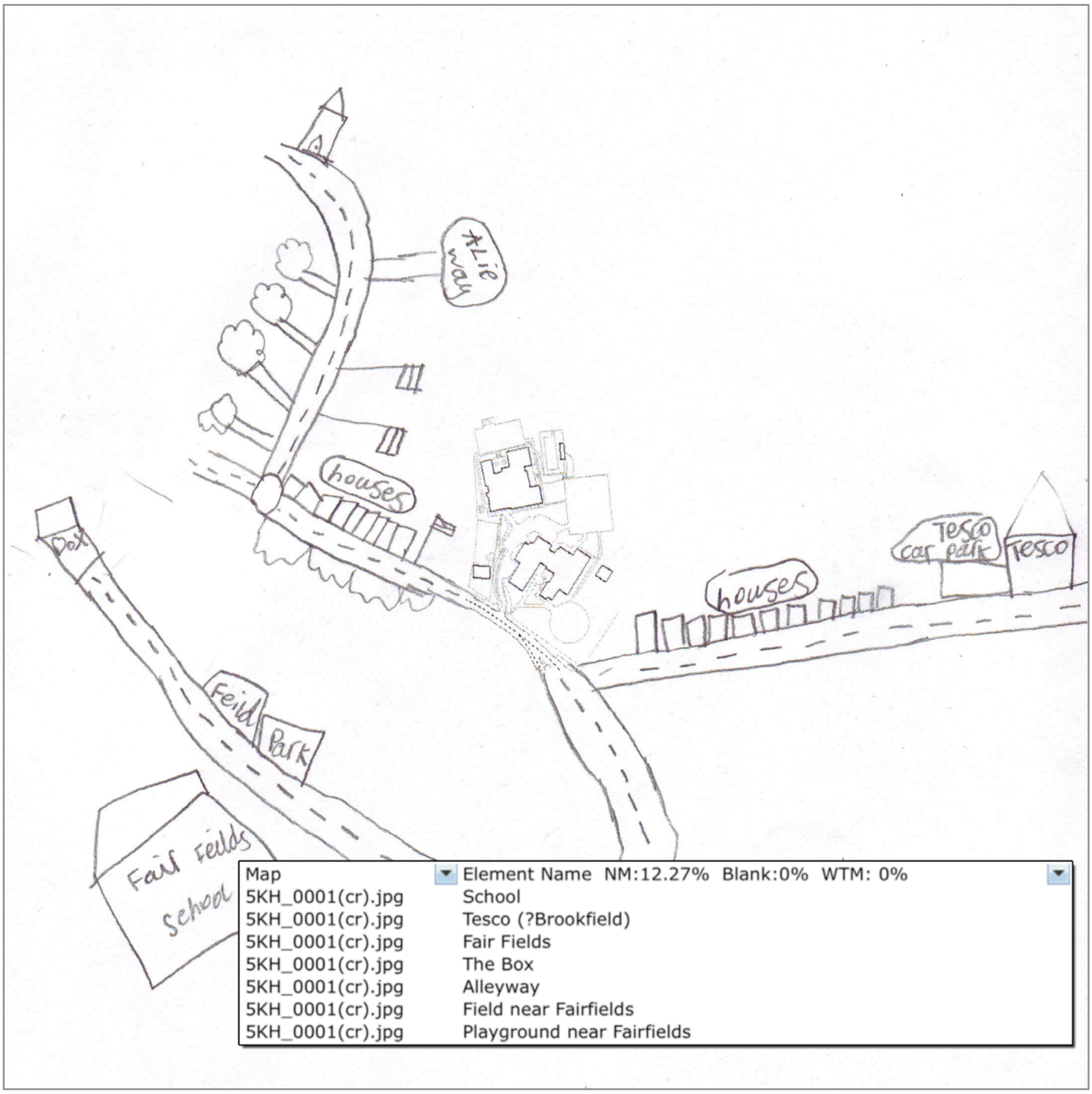


Figure 6-11: A scanned sketch map and the part of the spreadsheet showing how the names were recorded

An entry was made in the spreadsheet for each of the potentially identifiable elements. After examining all 278 area sketch maps the spreadsheet contained 1988 entries, each describing a potentially identifiable element. It was possible to find real-world matches for 1744 (88%) of these elements. The procedure for identifying the real world counterparts of the sketch map elements is described in the following sections.

6.2.5 Stage 5: Finding the sketch map elements in the real world

The process for finding the locations of the sketched elements in the real world positions made use of Ordnance Survey map data (OS MasterMap), the map data was supplied by Edina Digimap under a licence for academic research (© Crown

Copyright/database right (2011). An Ordnance Survey/EDINA supplied service). The downloaded maps were imported into a GIS package (Manifold GIS v8) to create a detailed base map of the study area, a view of the resulting map is shown below in Figure 6-12.

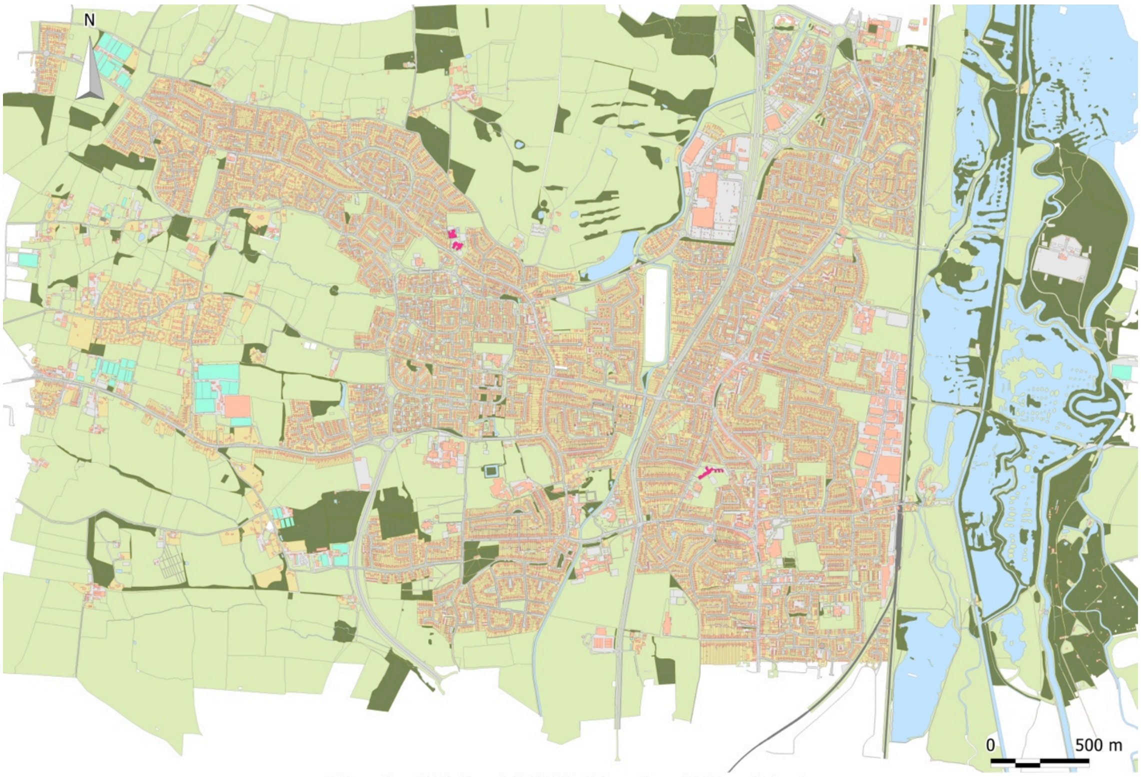


Figure 6-12: Ordnance Survey MasterMap coverage for Cheshunt

One reason for choosing OS MasterMap is that includes enough detail to identify individual buildings. The OS MasterMap data includes detailed annotations which are held in searchable tables. It was also desirable to have a base map that could be viewed clearly at any level of magnification.

MasterMap is a package of map data, the visual element of the map data (the data that describes the shape and position of the buildings, green spaces, roads, rivers, etc.) and the databases that contain map related information (including the annotations), are accessible separately. This allows the user to search the database tables for road names, building names, building types, etc. to try and match the information that a child has recorded in his or her map. Once the annotation has been found the GIS package is able to show the location where that annotation appears on the map. In this way elements like "Fairfields" in Figure 6-11 (above) could be found, or at least searched for, in the database, and the likely real world locations could then be displayed. As the work was conducted with primary school children there was a fair amount of misspelling, and unclear handwriting, this resulted in many instances where an initial search produced no results. One of the main challenges in processing the sketch map data was to decode what the child had intended to convey, this was aided by the ability to match partial text strings in the databases, which often returned more than one potential candidate.

The ability to search the database and view the location was also very helpful when trying to identify potentially ambiguous landmarks that had been drawn near to another element which had already been identified. There were, for instance, a number of unnamed roundabouts included in the children’s maps, many of these were drawn in close proximity to named buildings: near to the child’s school, or near to named shops, for instance. In the previous stage a reference to the nearby named element had been added to the reference for the element in question (“Roundabout near Marks and Spencers”, or “Park near Dig Dag Hill”). This allowed a search to be made for possible matches near the named element. In cases where there was little doubt about which roundabout or park was intended, a match was made. This does leave open the possibility that in some cases a wildly inaccurate placement was interpreted as a more accurate placement of a similar landmark type.

It has already been noted that a desirable feature of MasterMap data is that it can produce clear maps at a range of scales. This means that the map could be magnified to any level, and still provide a clear map image. This is possible because the data that provides the information about the map is stored either as text, which can be displayed at any size, or in a vector format where all the elements in the map are stored as line drawings. The alternative to vector based maps are maps based on bitmap data, these are essentially pictures made up of a series of pixels (picture elements). When a bitmap is scaled the individual pixels are scaled, at magnifications above 100% the pixel structure becomes increasingly obvious, and the maps begin to look blocky (see Figure 6-13). Figure 6-14 shows the result of magnifying the same area in MasterMap which does not result in obvious pixelation.

Figure 6-13: Magnifying a section of a bitmap results in obvious pixelation

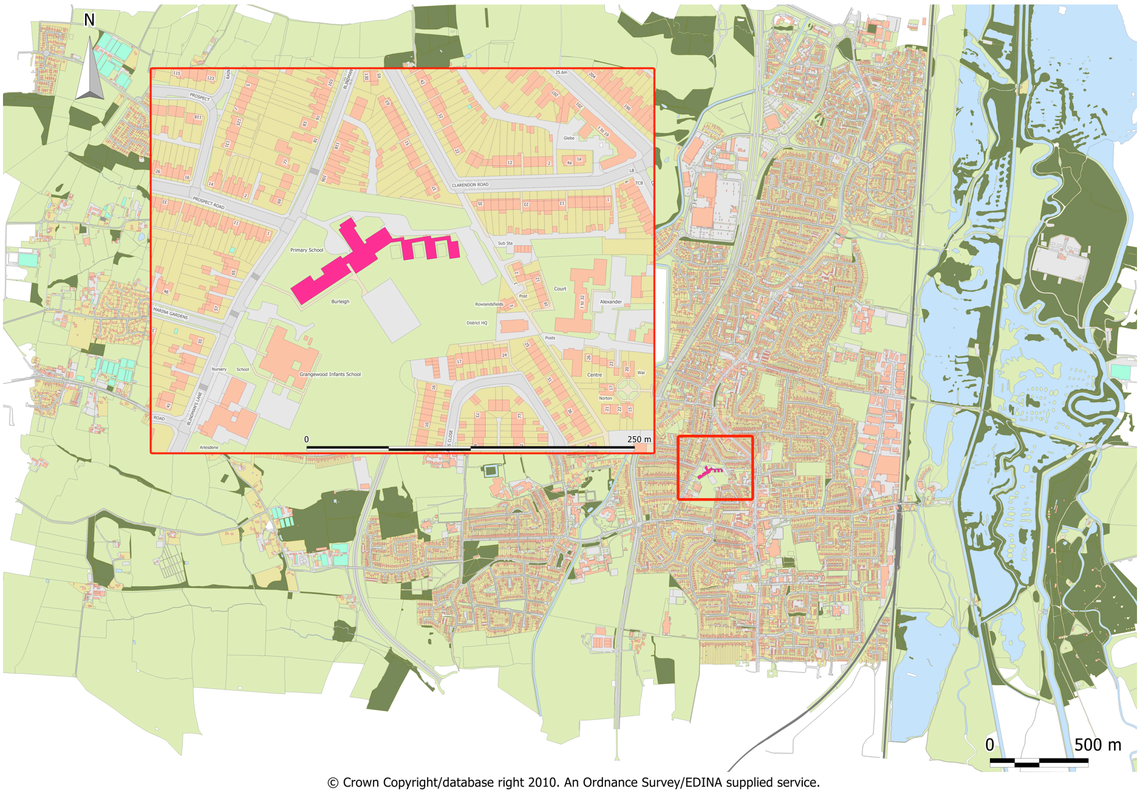


Figure 6-14: Magnifying a section of a vector map produces a clear map

Figure 6-15, below, shows a section of the map of Cheshunt together with two database tables. In this case (Figure 6-15) the tables show the position of postcode centre points, and the positions of elements that have already been identified from the Children's sketch maps.

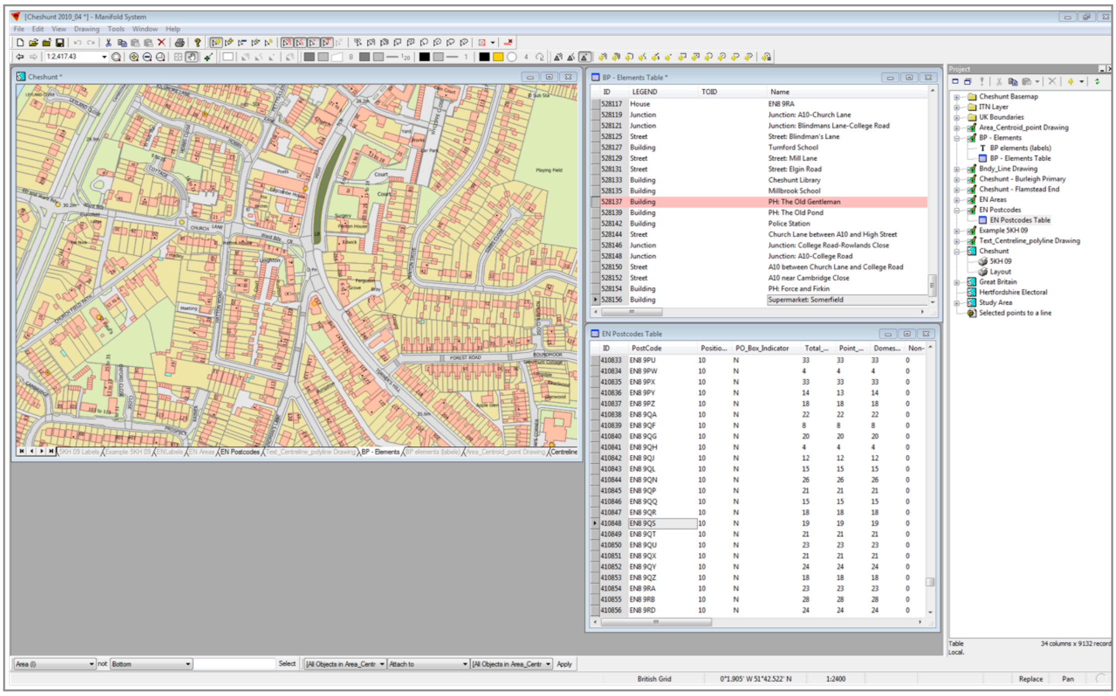


Figure 6-15: Screenshot of Manifold GIS version 9

Information from tables can be superimposed on the base map, as long as there are fields within the table that represent x and y coordinates; in the case of MasterMap data these are Eastings and Northings. OS Master Map uses the National Grid projection, which provides a simple 2-D coordinate system with orthogonal axes. A coordinate pair in this system is made up of an Easting, the x-coordinate, and a Northing, the y-coordinate. Each Easting, Northing pair measures the eastward and northward distances, respectively, from an origin to the south-west of the Isles of Scilly. The vertical direction is opposite to the way in which Photoshop specifies its pixel locations.

The number of digits in a British Grid Reference indicates its accuracy. The six digits in the Easting and the Northing figures used in this thesis indicate that that the coordinates specify a location to the nearest metre.

There were a number of occasions where it was not possible to make a clear identification using only the information supplied with the OS MasterMap data. In these cases the internet search engine Google was used in conjunction with Google Maps, the online mapping service, to identify possible matches.

Figure 6-16 below shows how a Google Maps search can be used to find identify the position of named elements in the real world. This example shows a search for public houses, or pubs. These were quite popular with the children at both schools, overall there were 38 inclusions of pubs, and eight different pubs names were given. This is presumably because of the colourful and distinctive designs of the buildings and their signs.

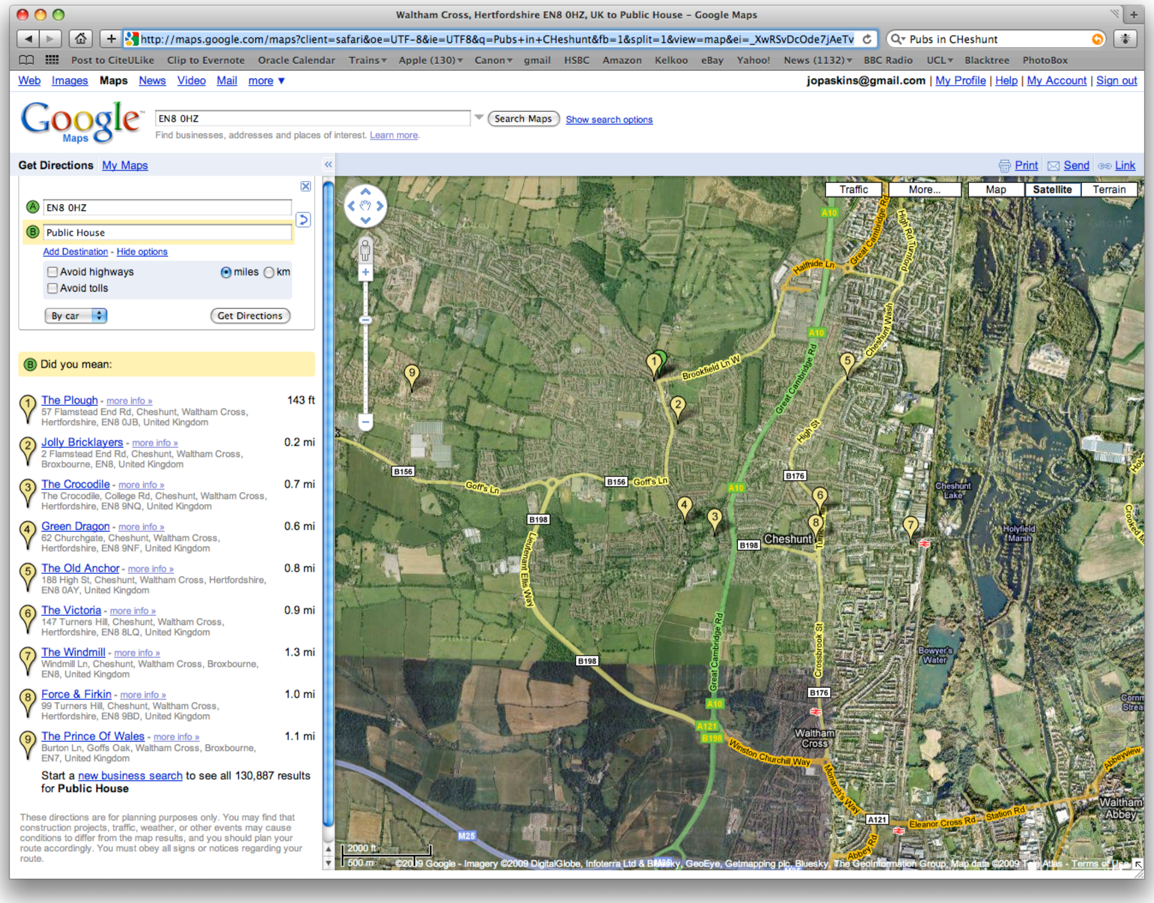


Figure 6-16: Using Google Maps to identify sketch map elements

The positions of the buildings in the Google map results are approximate, although often close to the actual position. It is often obvious from the shape of the building that the pointer is identifying the wrong building, for example it may be pointing to a building that is almost certainly a house rather than the one of the pubs mentioned by the children. One way to correct for the misplacement of the pointer in that example would be to choose the nearby building which appears to have a car park. However, there is a better way to overcome misplacements, and that is to use the Streetview function associated with Google Maps.

Where coverage exists, Google Maps Streetview, launched in 2007, allows the user to see street-level imagery. The imagery available is made up of a series of photographs taken from a car-mounted camera, and as such is only available along the sides of some roads. The Streetview coverage for Cheshunt is very good, and allowed the correct buildings to be identified in a large number of cases. Streetview is particularly useful when a shop or a pub name is given as the name of a landmark, it is then possible to "look" at the front of the building and check the name. An example can be seen in Figure 6-17, where the location of "Somerfield" has been established by using a Google search in conjunction with Google Maps and Street View.

Figure 6-17: Using Streetview to find the location of "Somerfield"

Figure 6-18: The red circle shows the building that has been identified in Google Maps as the Plough Public House

If we return to the pub, mentioned above, we can see how an initial search gives an inaccurate location. The red circle in Figure 6-18 shows the building which has been that is identified as the Plough Public House in Google Maps.

Once it has been determined that the building is not the correct match for the element in the child’s map, Google Maps and Streetview can be used to search the area around the indicated position to find the actual position of the building (Figure 6-19).

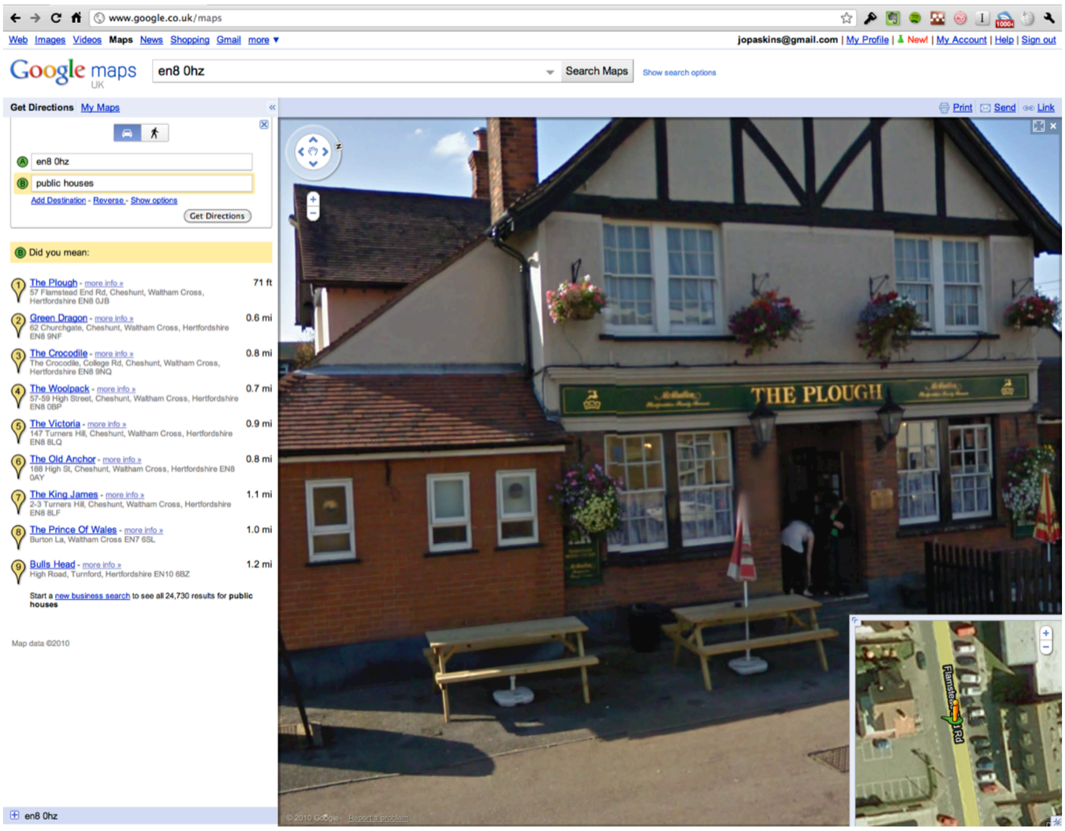


Figure 6-19: Finding the correct location of "The Plough"

In all cases the real world positions of the elements were found by using the cursor position in Manifold GIS. It is possible to configure the GIS package to report the current position of the cursor in terms of the currently selected coordinate system, see Figure 6-20. This allowed the real world positions of all the buildings to be determined in the same coordinate system (National Grid Eastings and Northings).

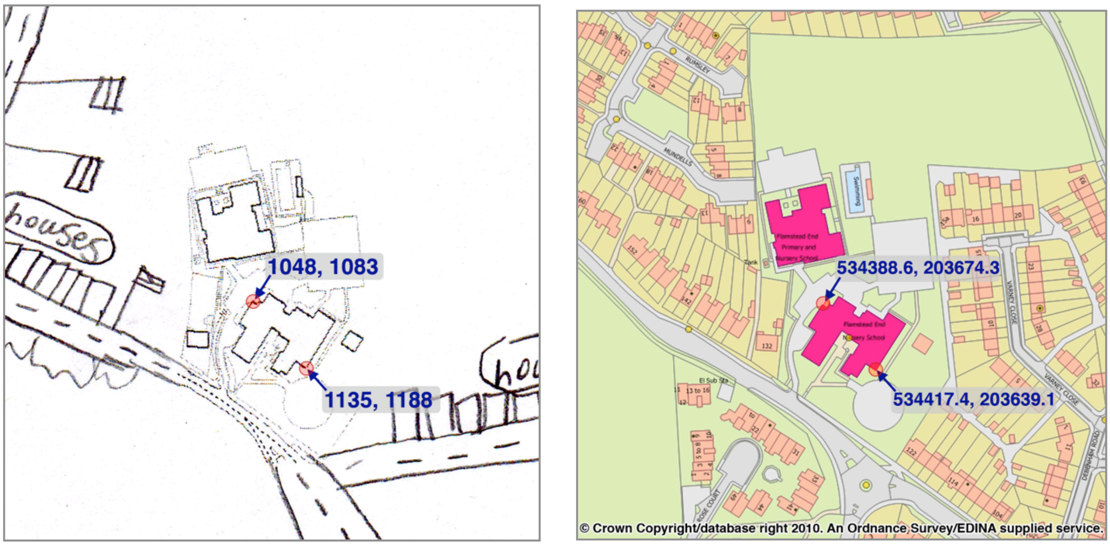


Figure 6-20: Position of the top left and bottom right corners of Flamstead End Primary School. Measured in pixels on the scanned image (shown on the left) and measured in metres on the Ordnance Survey map (shown on the right).

Not all elements were as straightforward to deal with, in the case of the homes of the participants, and their friends more steps were required.

6.2.6 Matching homes

Attempts were made to match the child's own home and friend's houses, if they were included in the map. The CAPABLE children's questionnaire asked for the name of the street they lived on and, if they knew it, their full postcode. To locate the child's home, when included as a sketch map element, the child's postcode was taken from his or her questionnaire, if present. Unfortunately in a number of cases the children's postcodes were missing, unreadable or did not exist in the postcode file downloaded from Edina Digimap. In order to improve the accuracy of the children's home locations it was necessary to check the address details given. Before using the postcodes recorded by the children it was necessary to go back to the paper questionnaires and check the data the children had supplied.

Postcode centre points were projected onto a map of Cheshunt in the GIS program. As the map data also included a searchable database of street names, it was then possible to check that the postcode, if given, was close to the street name the child had given. In many cases it was also possible to correct misreading of street name or postcode data.

The following steps were taken to locate as many home addresses as possible:

- In cases where a legible postcode and street address was supplied, both were located in the GIS package. In cases where there was a mismatch the postcode nearest to the street location was used, in many cases the postcode originally recorded resembled the postcode eventually used.
- In cases where a partially illegible street name was given, a partial match to the street name, together with a search for the postcode location were used to identify possible locations. In many cases the street name originally recorded could be recognised as an attempt to spell a street name near the postcode eventually used.
- In cases where no postcode was recorded, but a street name was supplied, a search was made for the street name (or partial street name, in cases with misspelling), and the postcode nearest the street, if a reasonable match could be found, was used.
- No check could be carried out on entries that did not include a street name.
- If no street name had been recorded on the questionnaire, the postcode was assumed to be correct, and where possible a street name was added to the entry.
- For entries outside the area covered by the OS MasterMap data, Google Maps was used to check the postcode instead of the Cheshunt map in the GIS package.

In some cases, such as those were the child hadn't recorded any postcode or street name information, no location information was recorded for the child's home. Where the information was recorded, or a location could be ascertained with a fair degree of certainty, the postcode centre point was used to give the location of the child's home.

In the case of a child's friend's home, some additional steps were required. It was only possible to place a friend's house if he or she was another child at the school who had completed the questionnaire. It was assumed that the child's friend would be in the same year. Most of the houses of friends are indicated on a sketch map with a first name, where there was more than one child in the class with the same first name, a match was not made.

6.2.7 Combining landmarks

In some cases it was necessary to make a judgement about the level of detail that should be considered when dealing with the sketch map elements. Below are examples of cases where it was considered that slight variations between children’s landmarks should be lost for the sake of clarity.

The first example is Stockwell Lodge Medical Village. The “Medical Village” is a grouping of related services, a dental surgery, a pharmacist and an optician. Children might include some or all of these as elements in close proximity on their sketch maps.

So, in this case the elements in the children’s maps were combined; when a combination including some or all of the elements (dental surgery, pharmacist and opticians) were placed in close proximity on the map, they were coded as ‘Stockwell Lodge Medical Village’, see Figure 6-21.

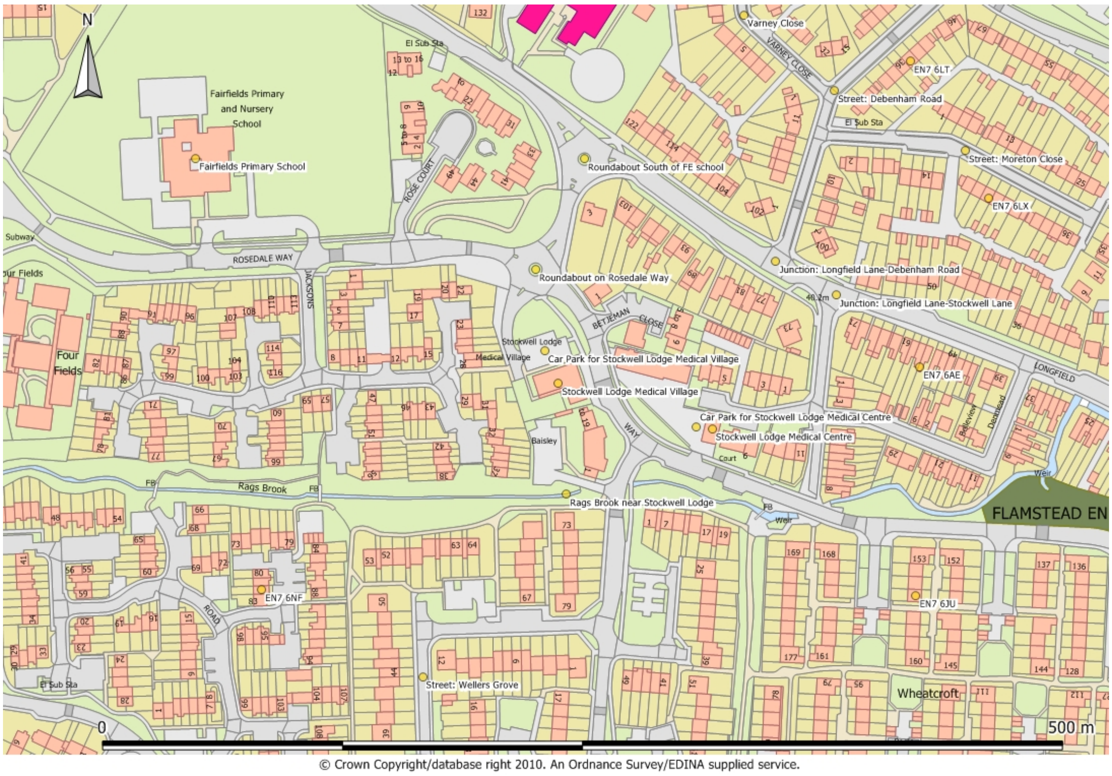


Figure 6-21: Stockwell Medical Lodge

The car park for Stockwell Lodge Medical Village has been included as a separate element. Another distinct element is the Stockwell Lodge Medical Centre, which houses the Medical General Practice.

The second example of a combination is that of the Post Office and Tesco Metro that were placed in close proximity to each other on the maps drawn by the children from Flamstead End Primary School. It seems clear from inspection of the Ordnance Survey map data and Google Streetview that a supermarket and a post office occupy the same relatively small building.

An example of a case where landmarks were not combined, is given by Brookfield Retail Park, see Figure 6-22. Also known, by the children, as Brookfield Farm, the retail park is an out of town shopping destination to the north-east of Cheshunt made up of a collection of large shops. The separate units for Brookfield Retail Park are large, much larger than the distance between the individual shops that make up Stockwell Lodge Medical Centre, so it was not felt necessary to combine these separate outlets into a single unit. The retail unit for the Next store alone appears to have a floor space of over 800m^2, whereas the combined floor space from all the separate shops in Stockwell Lodge Medical Village is less than 300m^2.

Figure 6-22: Brookfield Retail Park

6.2.8 Calculating a scaling factor for the sketch maps.

The measurements taken from the children’s sketch maps and the Ordnance Survey maps are in different units. Distances in the children’s sketch maps are measured in pixels, while distances in the Ordnance Survey maps are measured in metres.

It was decided to calculate a scaling factor for the area maps so that the position of the elements in the area sketch maps could be expressed in metres, rather than pixels. To do this it was first necessary to determine the distance between two fixed points in the sketched map data and the Ordnance Survey map data.

The worksheets given to the children to complete their area sketch maps featured an image of their school, Burleigh Primary School or Flamstead End Primary School, taken from an Ordnance Survey map. It was possible, therefore to use points on the image of the school in the scanned sketch map image and the Ordnance Survey data to produce a factor that can be used to scale pixels into metres.

Figure 6-23 below shows the two fixed points that were chosen in order to determine a centrepoint for the school building. Only one building has been considered because all of the children who completed the sketch mapping task at Flamstead End Primary School had their classrooms in the southern school building. The same pair of points was used as the comparison on the Ordnance Survey map.

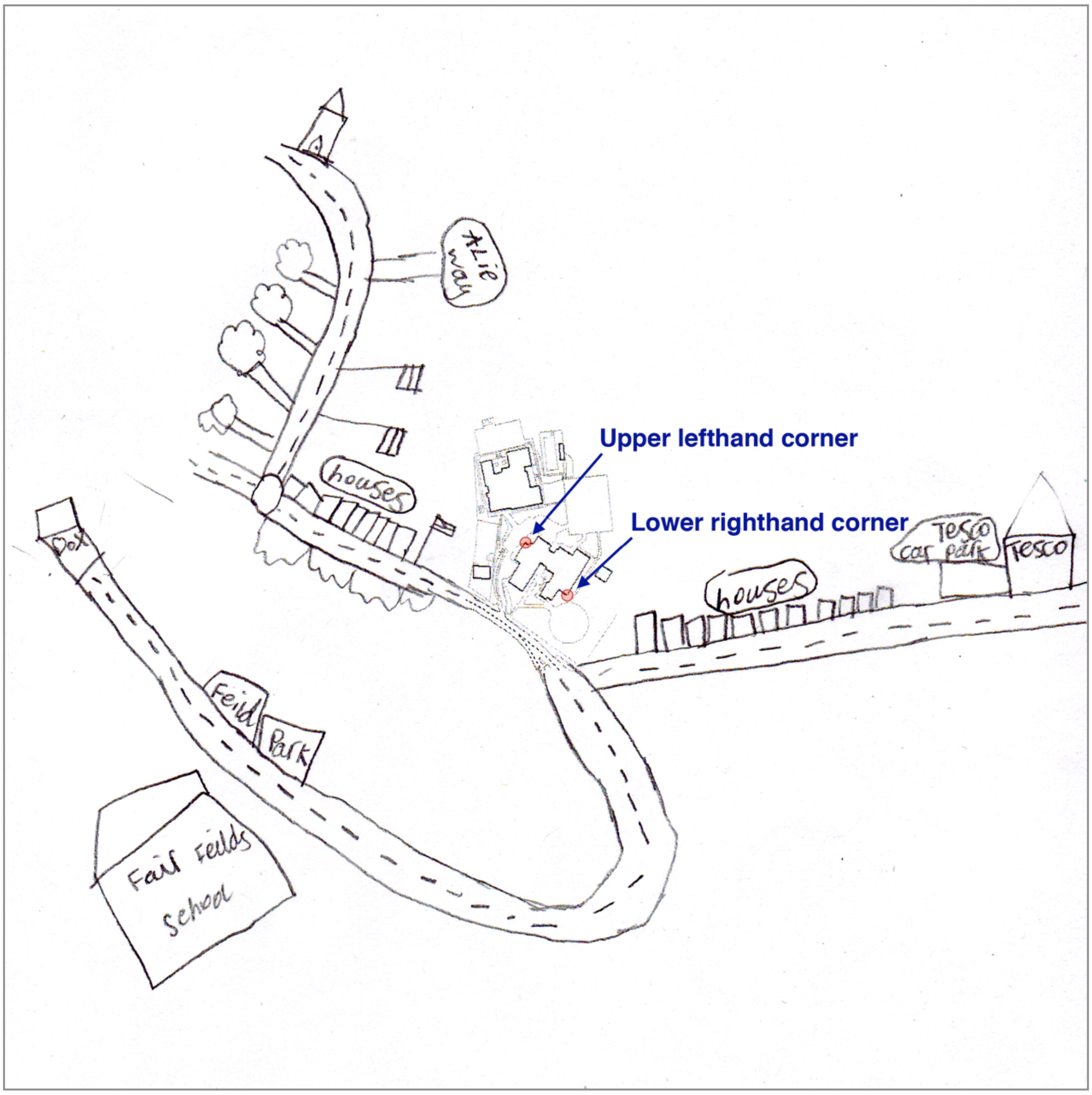


Figure 6-23: The top left-hand and bottom right-hand corners were used to calculate the centrepoint for the school building where the children drew their sketchmaps.

Figure 6-24 below shows the coordinates in pixels for the scanned image of the school in one of the children's sketch maps, along with the same pair of points on the Ordnance Survey map. There are differences in the locations of these points in different sketch map images, due to differences in alignment when scanning, slight differences in the placement of the cursor when using the Info tool in Photoshop and, most importantly, differences in the size of the image. The images vary in size because the images that were analysed are cropped sections from the worksheet given to the children. Each worksheet was cropped to remove the child's details. In some cases the drawing extended into the section for the child's details, where this happened the details were erased instead of cropped out.

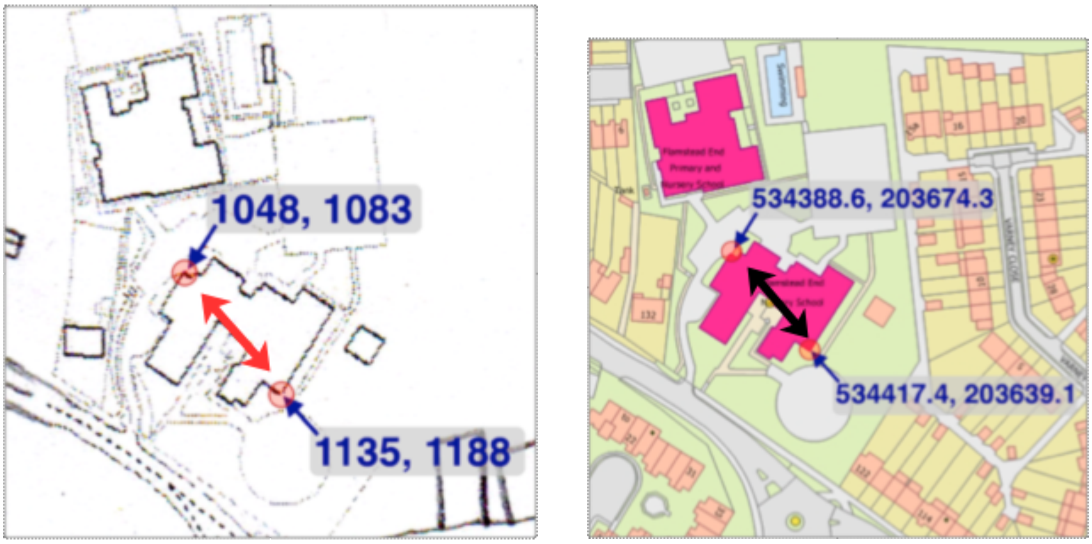


Figure 6-24: Position of the top left and bottom right corners of Flamstead End Primary School. Measured in pixels on the scanned image (shown on the left) and measured in metres on the Ordnance Survey map (shown on the right).

Pythagoras's Theorem can be used to calculate the distance between the two points in the scanned image, and for the same points in the Ordnance Survey data. The distances for the two schools remain constant for the mapped data, about 46m for Flamstead End Primary School and 87m for Burleigh Primary School.

Because the image of the school was not exactly the same size for each set of worksheets, each school has its own scaling factor. The scaling factor for Flamstead End sketch maps is around 0.34m, whereas sketch maps for Burleigh Primary have a scaling factor of around 0.45m.

If the scaling factor is applied to a sketch map sheet for Flamstead End Primary School (see Figure 6-25 below), we can see that all the elements, apart from the sun, are contained within a circle of diameter of 350m (based on the implied scale from the size of the school on the worksheet). The longest diagonal on the sketch mapping worksheet works out at around one kilometre.

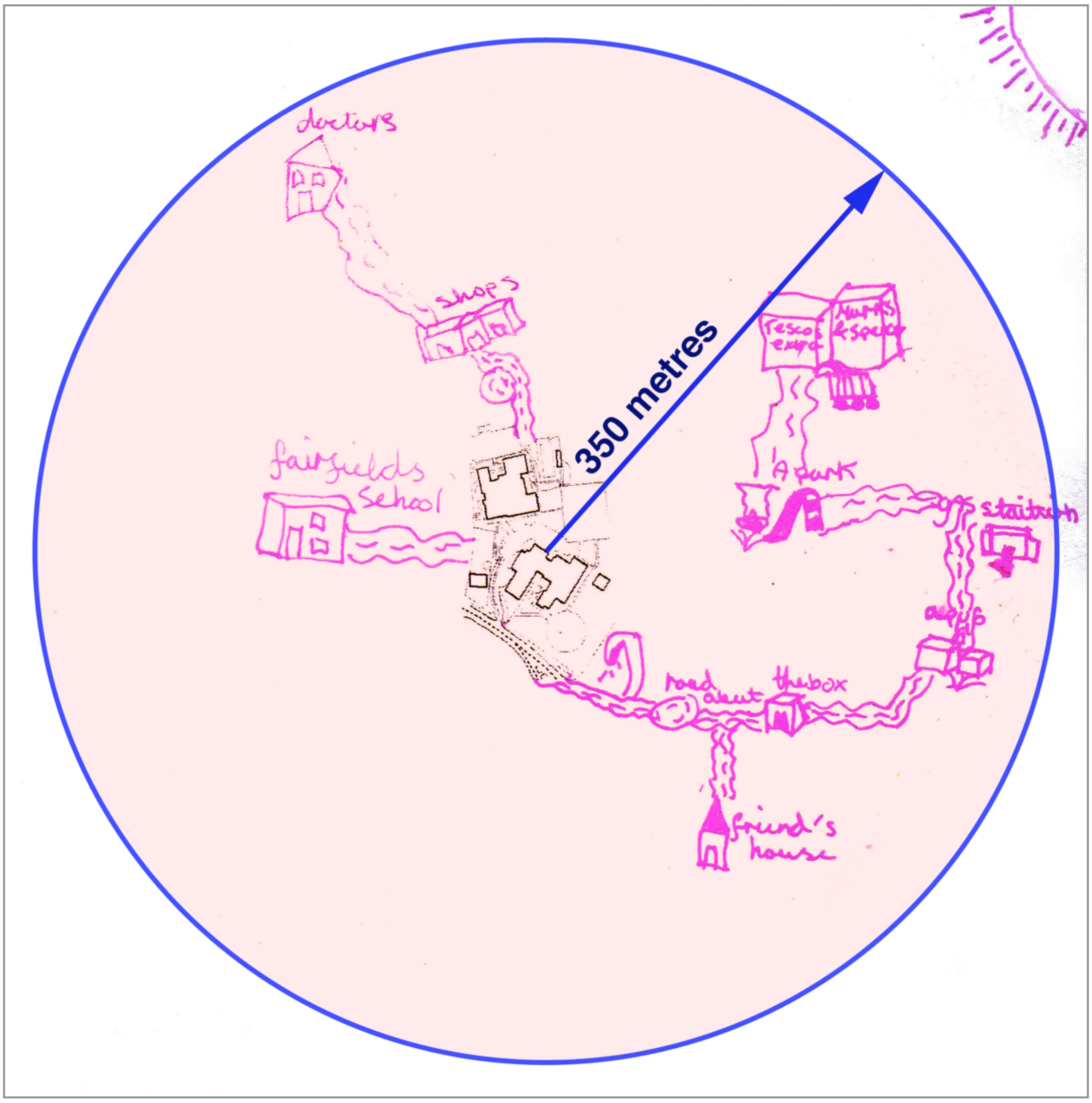


Figure 6-25: Area sketch map extent, based on the scale implied by the size of the image of the school

Figure 6-26, shown below, shows what is included in a circle of diameter 350m in the real world.

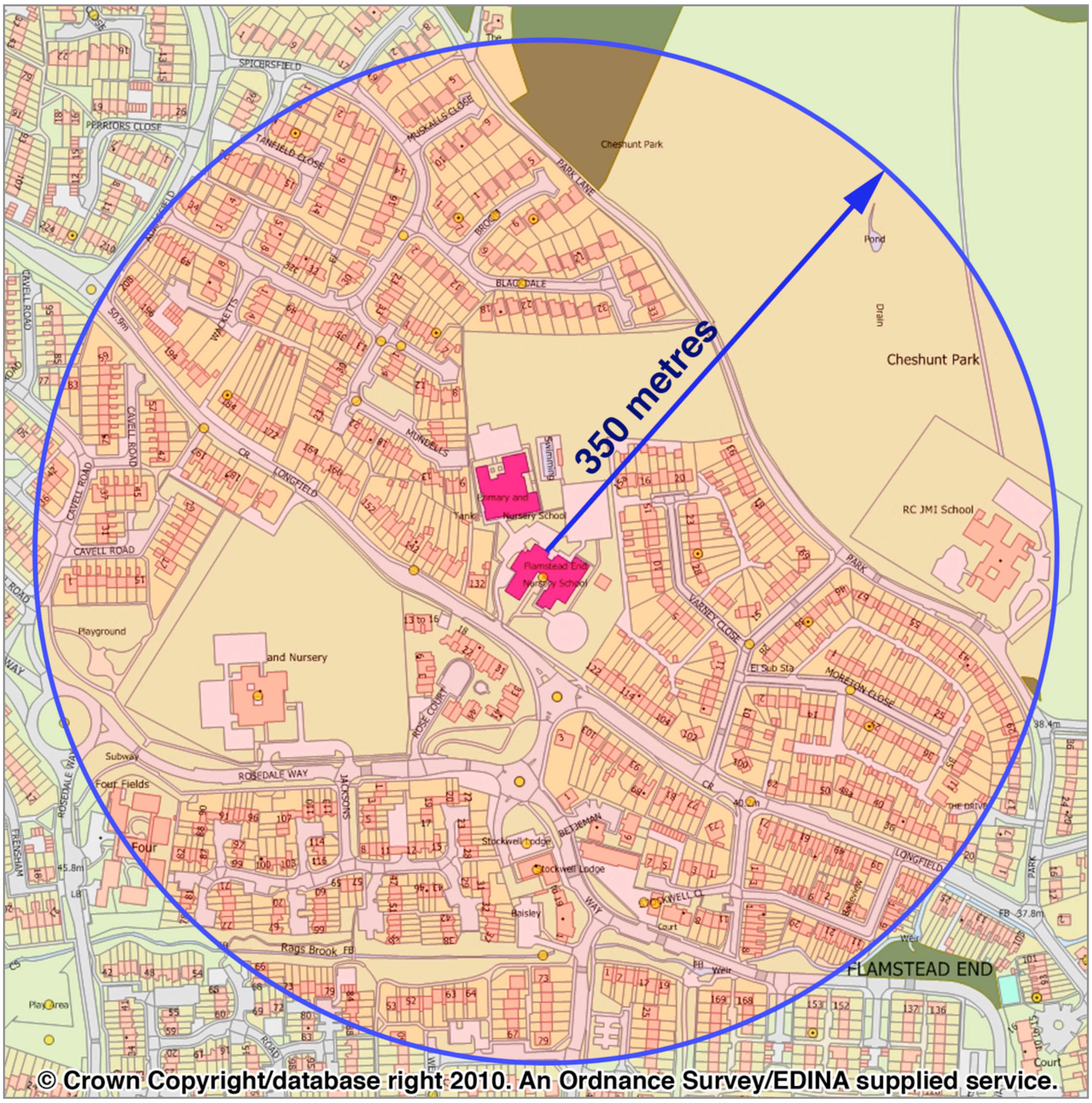


Figure 6-26: Map of Cheshunt showing the area covered by a circle of 350m centred on the school

It was never expected that the children would limit themselves in this way, they were asked to include "landmarks from the area around your school" with no explicit limit placed on the range that they could consider. If we exclude the sun, then the furthest landmark recorded in Figure 6-25 is a shopping centre, shown on the sketch map as "Tescos Express" and "Marks & Spencer", which is about 1250m away from the school.

The following figure (Figure 6-27) shows a map of the sketch map elements as they appear in the real world. When compared to the sketched map (Figure 6-25) it can be seen that the area they cover is not circular, and that the differences between the distances between the school and the objects are far more different than shown in the sketch map.

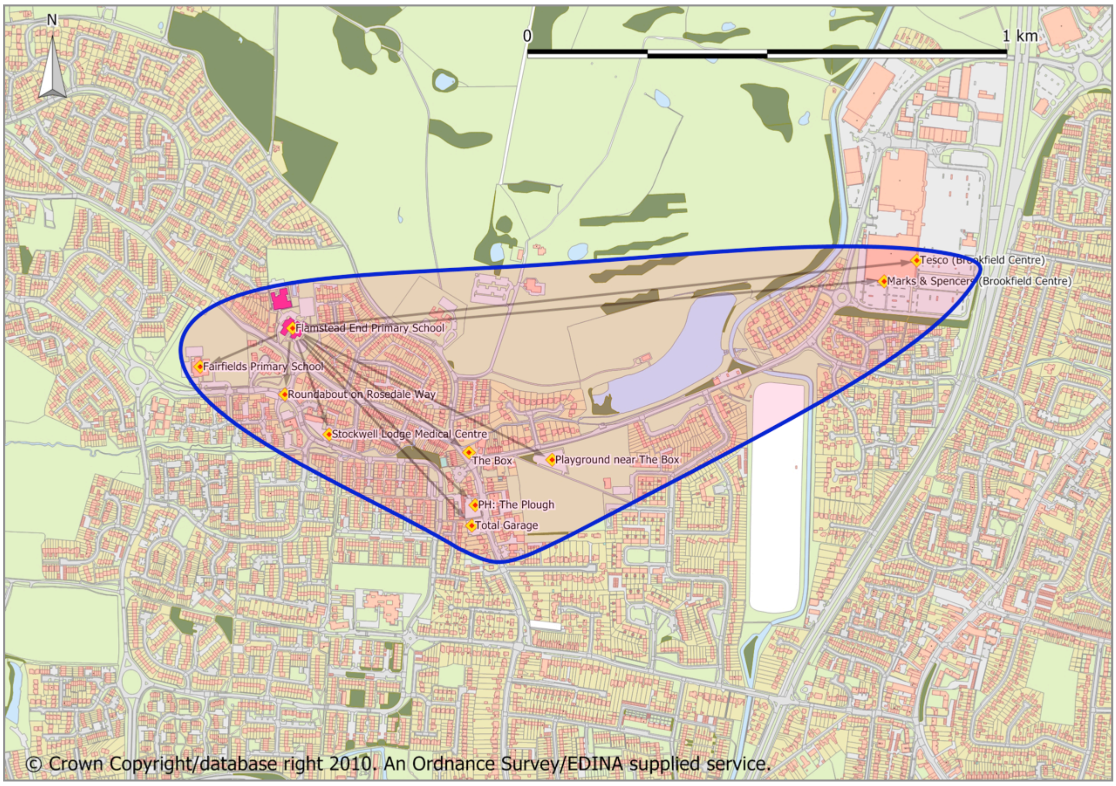


Figure 6-27: Comparison of the positions of sketched elements and their real world positions

6.3 Investigating accuracy with bidimensional regression

Bidimensional regression is a technique that can be used to assess the similarity of two sets of two-dimensional data. Friedman and Kohler give a very detailed description of the technique in their 2003 paper, (Friedman & Kohler, 2003). In the same paper they comment that although it is not a new technique, as it has been used in geography since at least the middle of the 1960s (Tobler, 1965), the technique is 'virtually unknown' in the psychological literature. Friedman and Kohler's paper was published in a psychology journal, and along with geography, psychology is one the main academic areas in which cognitive maps are a subject of research.

Bidimensional regression is analogous to standard correlation in that it seeks to find a best fit between two sets of data. In the case of standard bivariate correlation, the two sets of data are unidimensional, they are each described by a variable that alters along a single scale. Bidimensional regression extends this technique to include datasets that are described by the values in two dimensions, in the case of the data considered in this thesis those two dimensions represent displacement in orthogonal directions, or coordinates.

In this analysis the real world positions, those described by the latitude and longitude values derived from Ordnance Survey map data have been treated as the independent variables in the process. The positions of the sketch map elements as recorded by the children have been treated as the dependent variables. The configurations can also be given the names referent (for the independent variable) and variant (for the dependent variable).

The choice of which configuration plays the role of referent and variant has implications for the interpretation of the parameters that describe the transformations required to achieve the configuration of "best fit".

6.3.1 Analysis using bidimensional regression

Once the unambiguously identifiable elements, taken from the children's sketch maps, had been matched with their real world counterparts it was possible to run bidimensional regression for each child's configuration. As each map could contain any elements that the child recalled, it was necessary to process each configuration separately. The calculation of the bidimensional parameters was carried out using a spreadsheet made available by Friedman and Kohler (2003) as an appendix to their paper describing how the technique can be used to assess the similarity of maps, including cognitive maps.

It is possible to use the technique to deal with non-linear geometries (Tobler, 1994); this would not be inappropriate considering the distortions that are one of the characteristics of cognitive maps. It was, however, decided to use the Euclidean version to make both calculation and interpretation easier. In this model configurations are scaled, translated (moved) and rotated to achieve the best fit. These transformations apply equally to all points in the Euclidean model, giving a rigid transformation.

6.3.2 Additional parameters from bidimensional regression

As well as the r parameter that is returned by standard regression, or correlation, the bidimensional technique returns additional parameters describing the scaling, translation and rotation that are applied to the independent values to achieve the "best fit" between the two configurations. Rather than a fit line, the standard way to visualise the result of a correlation, bidimensional regression results in a best fit configuration. Figure 6-29 below gives examples of the three types of transformation that can be applied to the referent map (the independent variable, which in this research is represented by coordinate sets taken from the Ordnance Survey base map).

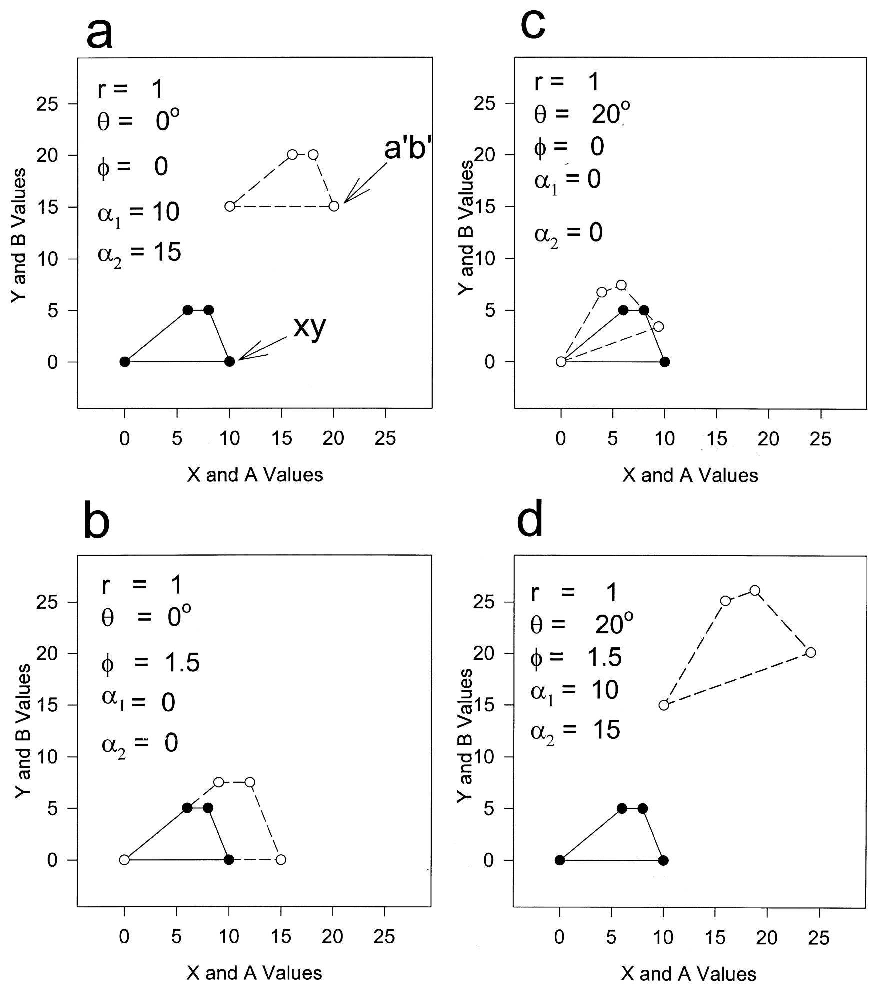


Figure 6-28: Four cases where configurations are perfectly correlated a: configurations differing only by translation; b: configurations differing only by scale; c: configurations differing only by rotation; d: configurations that differ in all three characteristics (Friedman & Kohler, 2003)

In the examples shown in Figure 6-28, above, the XY coordinates are the referent (the independent variable) in the regression and AB coordinates are the variant (the dependent variable). The A'B' coordinates describe the best fit configuration, which is essentially the referent after the translations have been applied.

The table below describes the variables and includes a note on how they should be interpreted in relation to the comparison of real world and sketch map data.

Scale (ϕ) represents the scaling factor that must be applied to the independent configuration to match the 'best fit' configuration. Values of **ϕ** that are less than 1 indicate that the independent configuration has to be reduced to fit the dependent configuration. In this analysis the independent configuration represents the real world and the dependent configuration represents the sketch map, so decreasing values of ϕ can be interpreted as the child representing more of the real world in their sketch map. Figure 6-29 shows an area map with a scale parameter of almost exactly 1 (1.01) indicating that his map very closely matched the implied scale given by the size of the school on the worksheet.

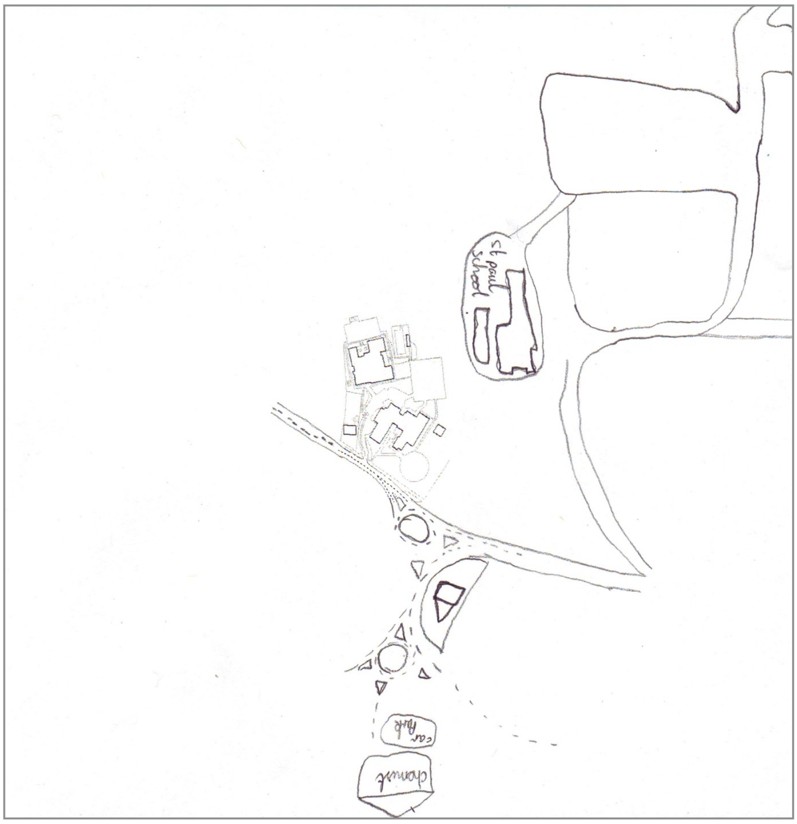


Figure 6-29: Sketch map with a scale that very closely matches that implied by the size of the school (FE6-001)

Angle (θ) represents the rotation that must be applied to the real world configuration to match the best fit configuration. Positive values for the angle represent counter clockwise rotations.

Alpha 1 (α_1) and **Alpha 2 (α_2)**: These two parameters represent the horizontal (α_1) and vertical (α_2) translations that must be applied to the referent to reach the least squares configuration.

Some descriptive statistics for the scaling and angle transformations are presented below. Figure 6-30, shown below, gives the average values for scale for boys and girls at both primary schools. There does not appear to be any clear pattern for map scale.

Boys at Flamstead End seem to show a general trend to include less area in their maps as they get older, but other groups show no clear trends.

6.3.3 Descriptive statistics for the sample

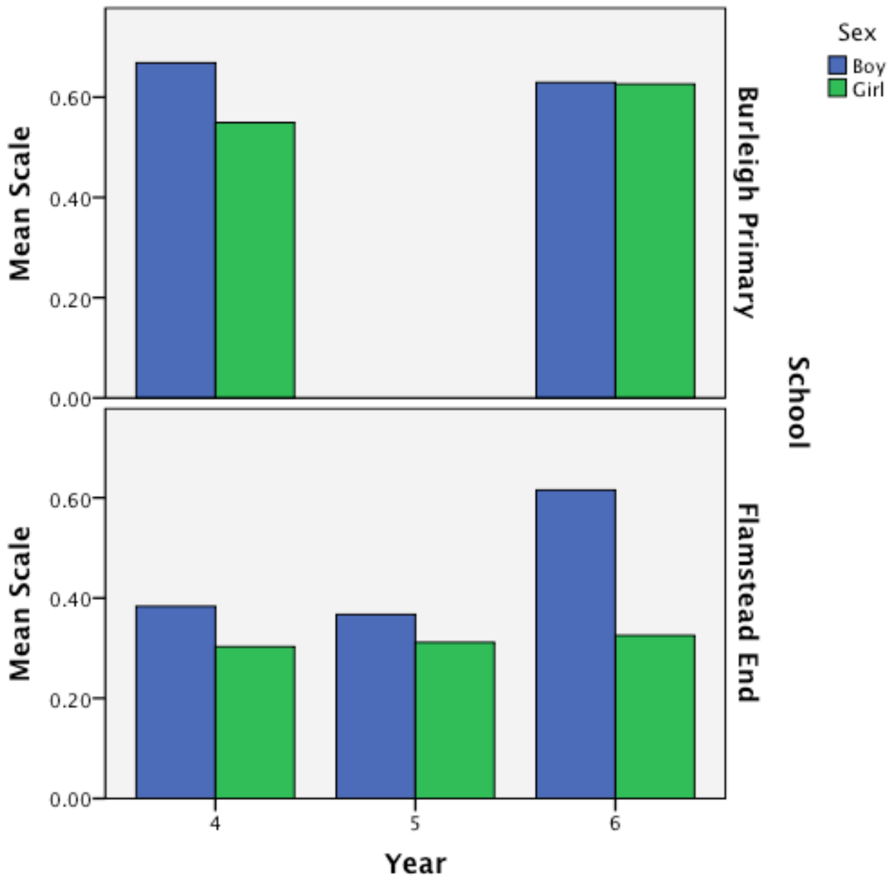


Figure 6-30: Mean values for the scaling factor, shown for boys and girls at the two Cheshunt schools

Figure 6-31, shown below, gives the average values for absolute displacement angle; the sign for the rotation angle has been dropped to concentrate on the size of the difference. Boys and girls at both primary schools show a clear trend of improved orientation as they get older.

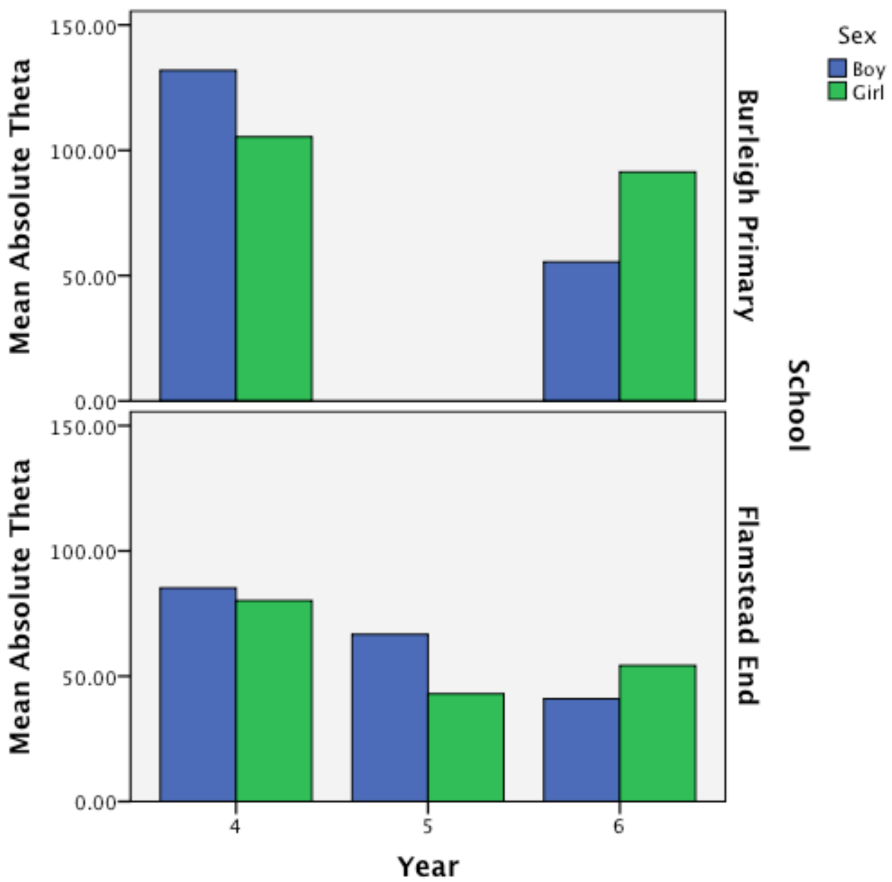


Figure 6-31: Mean values for the scaling absolute angle, shown for boys and girls at the two Cheshunt schools

6.4 Overall measure of distortion

Friedman and Kohler (2003) introduced a measure of overall map distortion that they labelled DI (Distortion Index). The measure is based on the level of unexplained variance between the referent and variant configurations. In the case of the data under consideration in this thesis, it is the unexplained variance after the Ordnance Survey base map has been scaled, rotated and translated to make the best possible fit with the child's sketched map. DI runs from 0, no unexplained variance, to 100, no fit between the referent and variant configurations. Figure 6-32, below, shows the most "distorted" map with a DI of 99.87, the scale 0.023 indicates that the child has tried to include a relatively large area in the sketch map.

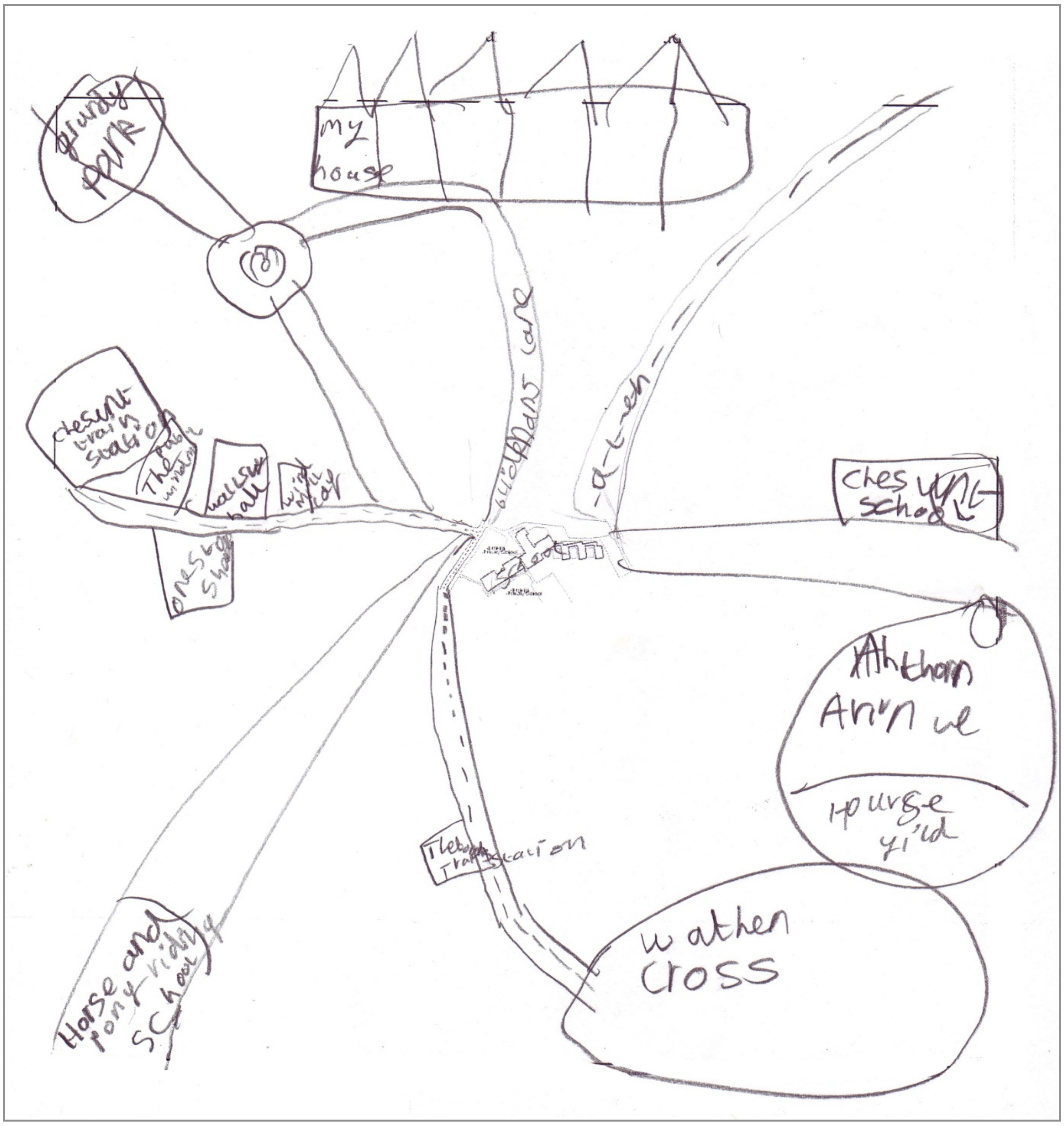


Figure 6-32: Most distorted map in the sample (BP4-047)

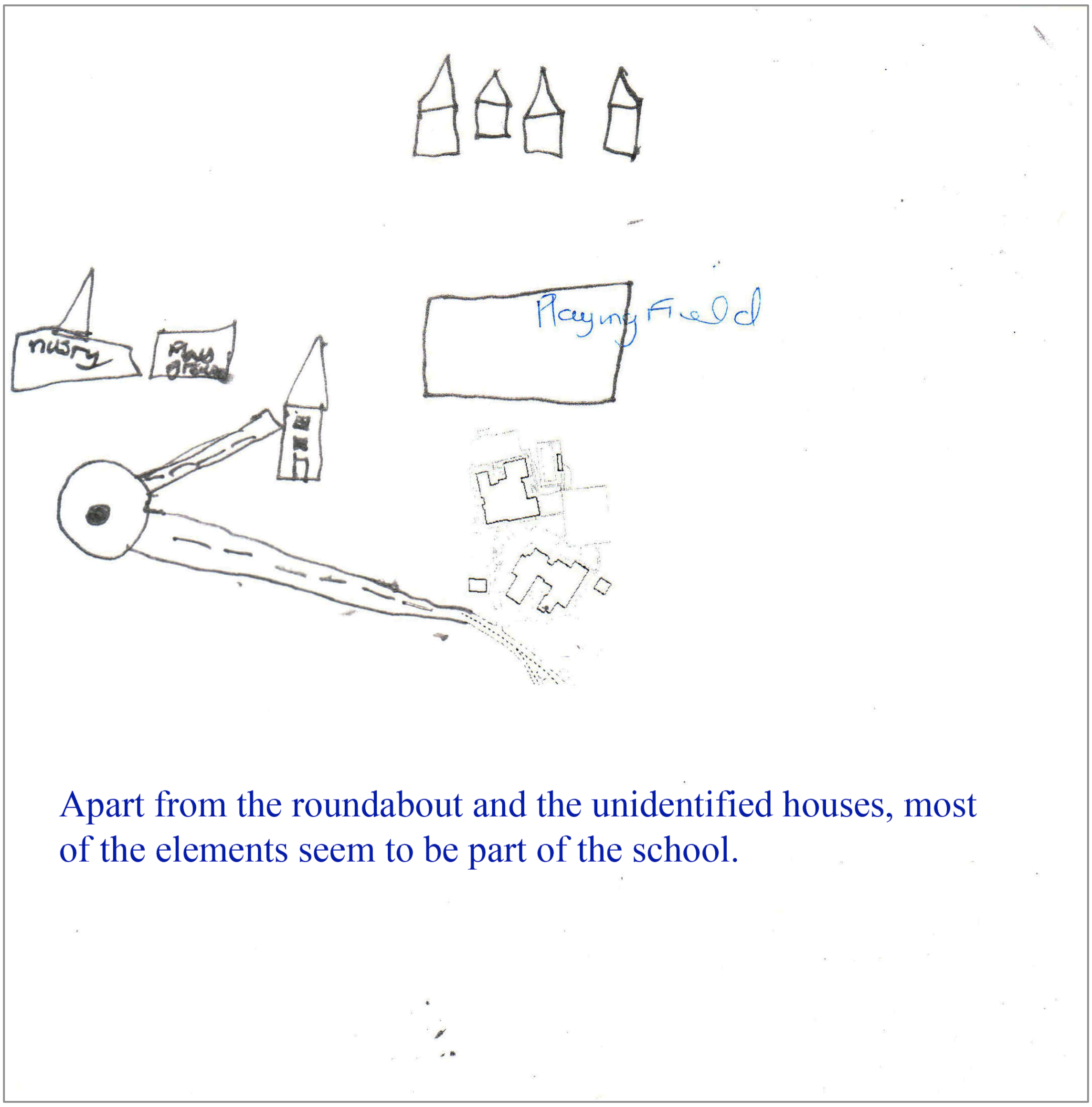


Figure 6-33: The least distorted map in the sample (FE4-041), the identifiable landmarks in this map cover a very small area

Most of the elements in the least distorted map (Figure 6-33) are part of the school. This maps covers one of the smallest areas of any of the maps: the scale parameter is by far the largest in the sample (ϕ =3.86 compared to an average of 0.47).

DI can be thought of as a measure how "bad" a particular sketch map is at representing the real world positions of the landmarks that have been included. Elsewhere in this thesis it will be easier to discuss how good the children's maps are. Also graphs become clearer if increasing values indicate better representations, rather than how distorted the representation is. For this reason DI has been slightly altered to produce a sketch map score. The alteration was simply to take the value of DI away from 100 (its maximum value).

6.5 Chapter summary

This chapter has covered the processes involved in taking a map that has been drawn by a child and converting it into a form that yields an objective measure of the accuracy of that child's cognitive map. The length of the chapter reflects the amount of processing that was required before analysis could begin. Children could recall any element from their local environment, in any style, with any spelling of its name. An effort was made to match all but the most generic of elements, starting with the OS MasterMap data, but the search for the real world positions often involved diversions into online maps, streetview and address searches.

The complications are worthwhile, as they have made it possible to deal with representations of a child's actual local environment, rather than working with small-scale abstract spatial problems. It is recognised that these measures are only an estimate, often underestimating a child's true cognitive mapping knowledge, but having a reasonably objective measure allows comparisons between different groups of children.

The bidimensional regression technique produces an overall measure for the distortion present in the child's sketch map. Statistics that describe the transformations that can be made to the real world landmark configuration to achieve a best fit configuration are also produced by this technique. These transformations are the two dimensional equivalent of a regression fit line equation. These descriptive statistics do not reveal a clear trend for map scale, but children get better at orienting their area sketch maps as they get older.

7 Factor analysis of the child questionnaire

7.1 The CAPABLE questionnaires

The sketch mapping activities were employed to reveal details of children cognitive representations of the local environment, in this study that knowledge, or at least the results from the sketch mapping tasks take on the role of the dependent variable. The independent variables, which describe the child and their travel behaviour, come in large part from a questionnaire about children's travel and activities.

Two questionnaires were used to gather information about the children and their activities. The child questionnaire (CQ) was designed for the pupils to complete at school, during lesson time. It was completed by all of the children who were present in the classroom on the day that the questionnaire was administered.

In addition to the child questionnaire, a questionnaire was given to the pupils to take home for their parents. A letter was included with this questionnaire, the parent questionnaire (PQ), the letter asked the pupil's parents to complete the questionnaire and return it to school. Once returned to the school, members of the fieldwork team collected the completed questionnaires. Unfortunately, the response rate for the parent questionnaire was much lower than for the child questionnaire.

Because of the low response rate for the parent questionnaire, this section will rely on the results of the pupil questionnaire.

7.2 Child questionnaire version

During the course of the CAPABLE project the questionnaire went through a number of revisions. Many of the early versions were developed before fieldwork began (version numbers were incremented to differentiate different draft versions) or were used in the pilot schools.

Although there was some variation in questionnaire versions there was enough similarity to allow comparison across the majority of questions, and the same version of the questionnaire was used in the two Cheshunt primary schools. The questionnaire used was "CAPABLE Primary School Pupil Questionnaire version 16", shown in Appendix 10. In addition to filling in their name and details for school and class, this version of the questionnaire asked the children to answer 44 questions. Some of the questions had multiple parts, including follow up questions, so the children were actually required to respond to up to 64 items.

The questionnaires were completed during lesson time, the researcher started by reading through the items in order, and asking the children to fill in the appropriate answer on their copy of the questionnaire (the children recorded their responses on their own doubled–sided A4 copy of the questionnaire). After the children had completed the first few questions in this way, they were allowed to complete the questionnaires at their own pace. The researcher then checked on the progress of the class and provided assistance where necessary.

The sample used in this research consists of the pupils in the last three years in the two primary schools in Cheshunt. The child questionnaire was completed by 330 pupils at the two Cheshunt schools. Table 7-1, below, shows the number of boys and girls at the two schools who completed the child questionnaire.

Table 7-1: Number of children who completed the child questionnaire by sex and school

	Boys	Girls	Total
Burleigh Primary School	82	78	160
Flamstead End Primary School	92	78	170
Both schools	174	156	330

It can be seen from Table 7-1, above, that a similar number of children completed the questionnaire at both schools. It can also be seen that a similar number of boys and girls were involved. Although the there are fewer girls overall, and at each school, a Chi-Square revealed that there is no significant difference between the numbers of boys and girls at the two schools χ^2 (1, N = 330) = 0.27, p = 0.60.

Table 7-2: Number of children who completed the questionnaire by age group

	Boys	Girls	Total
Year 4	64	48	112
Year 5	53	63	116
Year 6	57	45	102
All years	174	156	330

Table 7-2, above, shows the number of boys and girls in each year group (combining both schools). It can be seen from Table 7-2 that each of the three year groups has about the same number of children. Table 7-2 also shows that there are differences in the numbers of boys and girls in each of the year groups, in years 4 and 6 there are more boys, and in year 5 there are more girls. There is, however, no significant difference between the number of boys and girls in each of the year groups, χ^2 (2, N = 330) = 3.6, p = 0.17.

7.2.1 Aims of the child questionnaire

The questionnaire included items that gathered basic data describing the child. In addition to items about the school they attended, school year and sex, the questionnaire also included items about the child's age and the areas that they lived in.

The map below (Figure 7-1) shows the distribution of children at the two schools in the sample.

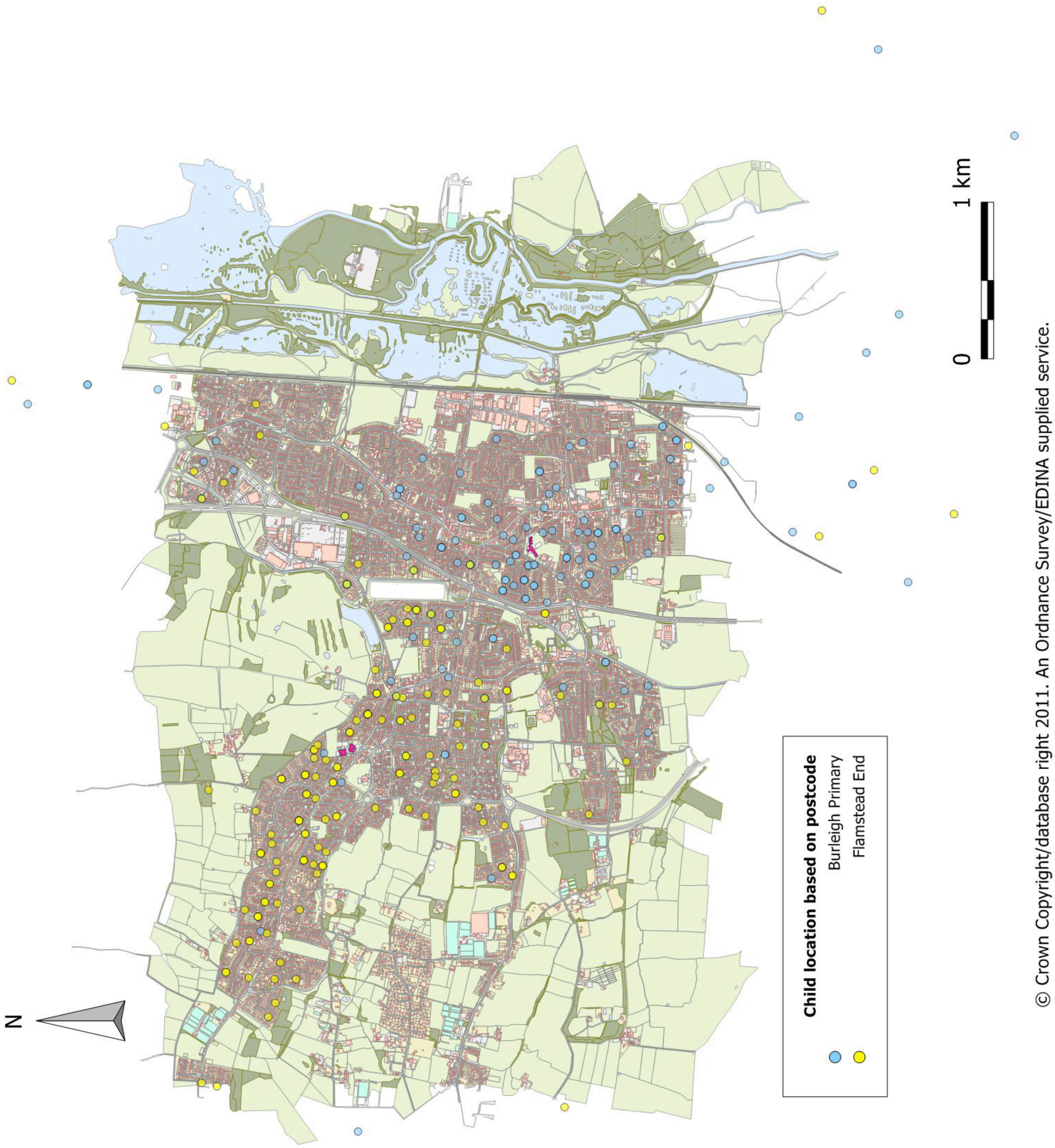


Figure 7-1: Map of Cheshunt showing the postcode locations for children at the two primary schools

It can be seen from Figure 7-1 that the sample is broadly split into two areas, with only a small overlap between the children who attend Flamstead End and Burleigh Primary Schools.

As well as collecting postcodes, and other basic descriptive data, for the children in the study, the child questionnaire was also designed to reveal information about the children’s behaviour. To do this the questionnaire included items that collected data under a number of themes, including travel mode, destinations visited and independent behaviour.

7.3 Conducting a factor analysis for the CAPABLE children’s questionnaire

Exploratory factor analysis was used to reduce the large number of items in the questionnaire down to a more manageable number of factors. Factor analysis can be used as a data reduction technique, converting a list of questionnaire items into a smaller number of factors, effectively summarising the questionnaire responses. The technique finds groups of questions that show common variation and groups them into co-varying factors.

In this analysis it will be assumed that the reason that, if answers to questions show similar variation, it is because they are measuring one of the themes the questionnaire was designed to investigate, for instance the child’s independence.

7.3.1 Data considerations for factor analysis

An important consideration is that the data should be of ordinal or ratio level. Nominal data, such as mode used for journeys, or sex of the child, is not suitable for this technique. In addition to excluding some items, it was necessary to recode some of the item responses to simplify the interpretation of the results of the analysis.

In the following analysis the questionnaire items will be referred to with a short reference number, the reference number takes the form CQ[question number], where CQ stands for child questionnaire. For example, question 1: “Are you a boy or a girl?”, would be referred to as CQ1. A list of all the questions is shown below

Item code	Original question
CQ1	Are you a boy or girl?
CQ2	What is your date of birth?
CQ3	What is the name of the street you live on?
CQ4	If you know our postcode, please write it below
CQ5a	Do you live in a *House/Flat in a house/Flat in a block*?
CQ5b	Do you have access to a *Garden/Communal area/Nearby park*?
CQ6	About how old were you when you moved to this address?
CQ7	Where are your parents from?
CQ8	How many adults live in your home?
CQ9a	How many brothers do you have?
CQ9b	How old are your brothers?
CQ10a	How many sisters do you have?
CQ10b	How old are your sisters?
CQ11	Which of the following relatives live locally (within 20 minutes from your home)? *Grandparent(s) (mother's and father's side); Aunt or Uncle (mother's and father's side)*
CQ12	How many cars are there at home?
CQ13	Do you own or use any of the following? *Scooter/Skateboard/Rollerblades or Rollerskates*
CQ14	How long does it usually take you to get to school?
CQ15	How do you usually travel from home to school?
CQ16	Whom do you travel to school with?
CQ17	How long does it usually take you to get home from school?
CQ18	How do you usually travel home from school?
CQ19	Whom do you travel from school with?
CQ20	Are you allowed out on your own?
CQ21	How often do you make a trip by car (excluding school journeys)?
CQ22	How often do you make a trip by bus (excluding school journeys)?
CQ23	How old were you when you were first allowed to travel on buses without an adult?
CQ24	Can you ride a bicycle?
CQ25	Do you own a bicycle?
CQ26	How often do make a trip by bicycle (excluding school journeys)?
CQ27	Are you allowed to cycle on main roads without an adult?
CQ28	How often do you walk somewhere (apart from going to school)?
CQ29	Are you allowed to go for a walk on your own?
CQ30	From what age were you allowed to cross main roads without an adult?
CQ31	During a normal week how often do you go to organised activities?
CQ32	What is the total amount of time you spend on organised activities from Monday to Friday?
CQ33	What is the total amount of time you spend on organised activities at the weekend?
CQ34	How do you usually travel to organised activities?
CQ35	Whom do you travel with when you go to organised activities?
CQ36	How many friends' houses do you visit?
CQ37	How do you usually travel when you go to visit your friend's houses?
CQ38	When you go to visit your friends do you usually go on your own?
CQ39	How old were you when you were first allowed to go to friend's houses without an adult?
CQ40a	During a normal week if the weather is good how often do you stay at home when you get back from school?
CQ40b	During a normal week if the weather is good how often do you go to a friend's house?
CQ40c	During a normal week if the weather is good how often do you go somewhere else which is outdoors (e.g. street, park, woods, etc.)?
CQ40d	During a normal week if the weather is good how often do you go somewhere indoors (e.g. leisure or shopping centre, swimming pool, etc.)?
CQ41	How much time do you spend out of the house at the weekend?
CQ42	How much time do you spend out of the house after school during the week?
CQ43a	Do you visit any of the following places alone, only with friends or with an adult? – **Local shops**
CQ43b	Do you visit any of the following places alone, only with friends or with an adult? – **Shopping centres**
CQ43c	Do you visit any of the following places alone, only with friends or with an adult? – **Cinema**
CQ43d	Do you visit any of the following places alone, only with friends or with an adult? – **Sports facilities**
CQ43e	Do you visit any of the following places alone, only with friends or with an adult? – **Park**
CQ44	What is the total amount of time you spend during a week watching TV (including videos and DVDs), using a computer or playing on a games console?

7.3.2 Notes on processing the questionnaire data

Data for the questionnaire responses were entered into an excel spreadsheet, with each row in the spreadsheet representing one child's set of responses. The items on the questionnaire used either tick boxes, a text box, or in some case both, for the child's response. The most straightforward items are those that require one check box to be ticked, these are coded with a single number indicating the response. Items with a text box response were recorded as free text. For those questions that allowed more than one tick box to be completed, or that mixed tick boxes and text boxes, more than one column has been used to record the responses.

7.3.3 Recoding the questionnaire data

7.3.3.1 Accompaniment and level of independence

Some of the items in the questionnaire, such as "What is the name of the street that you live on?" (CQ3) and "Where are your parents from?" (CQ7) are not suitable for factor analysis. Some of the other questions required recoding before they could be included in the questionnaire. For instance, questions about who accompanied the child on different journeys, questions which allowed multiple boxes to be ticked to indicate who travels with the child, were recast as questions about the child's level of independence. This was done by assigning a score based on the least independent response in the set, see Table 7-3.

Table 7-3: Relating independence to level of accompaniment in the child questionnaire

Questionnaire option	**Score**
Travel with a parent or another adult, or only allowed with an adult	1
Travel with brother or sister, or only allowed with older sibling	2
Travel with friends, or only allowed with friends	3
Travel alone, or allowed to do the activity alone	4

If, for instance, a child had ticked two boxes to indicate that they went to school with both their friends and with an adult, the response would be given a score of 1. This is because travelling with an adult is the least independent part of the response.

7.3.4 Age for independent behaviours

There are a number of items in the questionnaire that ask the child to fill in the age at which they were allowed to undertake behaviours without adult accompaniment.

For example CQ30 asks "From what age were you allowed to cross main roads without an adult?". The possible responses are an age, or to tick a box to indicate "I'm not allowed". To aid in the analysis of the questionnaire the responses have been recoded into *number of years the child has been allowed to carry out the behaviour without an adult*. To do this responses are recoded as the difference between the child's current age and the age at which the behaviour was allowed. Because scores of zero indicate cases where children are the same age as the age when allowed to carry out the behaviour, responses of "I'm not allowed" have been coded as -1.

7.3.4.1 Calculating ages

The researcher recorded the date that the questionnaire was administered, and the child was asked for their date of birth in one of the items. The age of the child in years was calculated as the number of years (to 2 d.p.) between the date of birth and the date the questionnaire was administered. In the 66 cases where the date of birth was missing, illegible or improbable, an average for that class, has been used (see Table 7-4 below for average ages in each class).

Table 7-4: Average age, by class, for children who recorded their date of birth

Class	Average age (years)
4CW	8.84
4LB	9.08
4RM	8.87
4SF	9.05
5AH	10.11
5AL	10.05
5CL	10.16
5KH	10.12
6CM	11.16
6KM	11.00
6NN	10.99
6NR	11.47

7.3.4.2 Number of friend's houses

CQ36, asking the child to indicate how many friends' houses they visited "How many friends house's do you visit?" attracted a number of a very wide range of values, including some very high numbers. Because it is increasingly unlikely that the children really are allowed to visit 100, 1,000 or 10,000 other children's houses it was decided to convert the responses into a series of categories, each with around 10% of the responses. This resulted in the following categories: 1, 2, 3, 4, 5, 6, 7, 8–10, 11–20, 21+. An additional category was created for all the values of 0.

7.3.5 Questions considered for inclusion in the factor analysis

The questions shown in Table 7-5 were included in the initial factor analysis, while those in Table 7-6 were excluded. The final analysis did not include all the items in Table 7-5.

Table 7-5: Questions considered for inclusion in the factor analysis with original and recoded responses

Item code	Equivalent restructured question	Recoded question response
CQ2	Age (years)	Age of the child based on date of birth and the date of the questionnaire – Ratio data
CQ6	Years at current address	Length of time in years based on start age – Ratio data
CQ14	Travel time – to school	Time categories 1–6[a] – Ordinal data
CQ16	Independence – to school	Independence categories 1–4 – Ordinal data
CQ17	Travel time – from school	Time categories 1–6[a] – Ordinal data
CQ19	Independence – from school	Independence categories 1–4 – Ordinal data
CQ20	Independence – other journeys	Independence categories 1–4 – Ordinal data
CQ21	Frequency – car journeys	Frequency categories 0-4 – Ordinal data
CQ22	Frequency – bus journeys	Frequency categories 0-4 – Ordinal data
CQ23	Independent years – bus	Length of time in years based on current age (-1 for not allowed) – Ratio data (scale)
CQ26	Frequency – bicycle journeys	Frequency categories 0-4 – Ordinal data
CQ27	Independent years – bicycle	Independence categories 1–4 – Ordinal data
CQ28	Frequency – walking journeys	Frequency categories 0-4 – Ordinal data
CQ29	Independent years – walk	Independence categories 1–4 – Ordinal data
CQ30	Years – crossing main road without adult	Length of time in years based on start age – Ratio data
CQ31	Frequency – organised activities	Frequency categories 0-4 – Ordinal data
CQ32	Amount of time – organised activities (week)	Time categories 0–3[b] – Ordinal data
CQ33	Amount of time – organised activities (weekend)	Time categories 0–3[b] – Ordinal data
CQ35	Independence – organised activities	Independence categories 1–4 – Ordinal data
CQ36	Number friend's houses	Categories based on 10% of responses
CQ38	Independence – friend's houses	Independence categories 1–4 – Ordinal data
CQ39	Independent years – visiting friend's houses	Length of time in years based on current age (-1 for not allowed) – Ratio data (scale)
CQ40a	Frequency	Frequency categories 0–4 – Ordinal data
CQ40b	Frequency	Frequency categories 0–4 – Ordinal data
CQ40c	Frequency	Frequency categories 0–4 – Ordinal data
CQ40d	Frequency	Frequency categories 0–4 – Ordinal data
CQ41	Time out of the house – weekdays	Time Categories 1–4[c] – Ordinal data
CQ42	Time out of the house – weekends	Time Categories 1–4[c] – Ordinal data
CQ43a	Independence - Local shops	Independence categories 1–4 – Ordinal data
CQ43b	Independence - Shopping Centre	Independence categories 1–4 – Ordinal data
CQ43c	Independence - Cinema	Independence categories 1–4 – Ordinal data
CQ43d	Independence - Sports facilities	Independence categories 1–4 – Ordinal data
CQ43e	Independence - Park	Independence categories 1–4 – Ordinal data
CQ44	Screentime – time watching TV and using the computer	Time Categories 1–6[d] – Ordinal data

a: Time categories 1–6: 1 = "Less than 5 minutes"; 2 = "5–10 minutes"; 3 = "10–15 minutes"; 4 = "15–30 minutes"; 5 = "30 minutes–1 hour"; 6 = "Over an hour"
b: Time categories 0–3: 0 = "No time"; 1 = "Less than half an hour"; 2 = "Half an hour to an hour"; 3 = "More than half an hour"
c: Time categories 1–4: 1 = "0-3 hours"; 2 = "3–6 hours"; 3 = "6–9 hours"; 4 = "9 hours or more"
d: Time categories 1–6: 1 = "Under 1 hour"; 2 = "1–4 hours"; 3 = "4–8 hours"; 4 = "8–12 hours"; 5 = "12–16 hours"; 6 = "Over 16 hours"

Table 7-6: Questions that were not included in the factor analysis

Item code	Original question	Data type
CQ1	Are you a boy or a girl?	Nominal
CQ2	What is your date of birth?	Text
CQ3	If you know your postcode, please write it below	Text
CQ5a	Do you live in a house/flat in a house/flat in a block	Nominal
CQ5b	Do you have access to a garden/communal area/nearby park	Nominal
CQ7	Where are your parents from?	Text
CQ8	How many adults live in your home?	Ordinal
CQ9	How many brothers do you have? How old are your brothers?	Ratio
CQ10	How many sisters do you have? How old are your sisters?	Ratio
CQ11	Which of the following relatives live locally (within 20 minutes from your home)?	Nominal
CQ12	How many cars are there at home?	Ratio
CQ13	Do you own or use any of the following? Scooter/Skateboard/Rollerblades	Nominal
CQ15	How do you usually travel home to school?	Nominal
CQ16	How do you usually travel home from school?	Nominal
CQ24	Can you ride a bicycle?	Nominal
CQ25	Do you own a bicycle?	Nominal
CQ34	How do you usually travel to organised activities?	Nominal
CQ37	How do you usually travel when you go to visit your friends' houses?	Nominal

7.3.6 Initial exploratory factor analysis and refining the factor analysis

There are a number of considerations for the items that will be included in the factor analysis. SPSS reports a number of useful descriptive statistics that can guide the decisions about the inclusion and exclusion of the questionnaire items, including a correlation matrix with a determinant value, KMO and Bartlett's tests (Field, 2005). The following paragraphs will discuss the steps taken to meet the requirements for the factor analysis.

The initial factor analysis contained the following 33 questionnaire items:

CQ6 CQ14 CQ16 CQ17 CQ19 CQ20 CQ21 CQ22 CQ23 CQ26 CQ27 CQ28 CQ29 CQ30 CQ31 CQ32 CQ33 CQ35 CQ36 CQ38 CQ39 CQ40a CQ40b CQ40c CQ40d CQ41 CQ42 CQ43a CQ43b CQ43c CQ43d CQ43e CQ44

For more details about any of the questionnaire items, please see the descriptions in Section 8.3.1.

The first stage in the analysis was to determine whether the list of questionnaire items was suitable for this technique. A table of the correlations for all the questionnaire items under consideration was produced, as a first stage of an initial factor analysis. This initial run revealed that the matrix was not positive definite, and therefore not suitable for analysis. Examining the correlation matrix revealed that items CQ14 and CQ17, (which asked about the time taken to travel to, and from, school) were perfectly correlated. Removing CQ17 from the analysis resolved this problem.

A second factor analysis, using the remaining 32 items, was conducted. Along with the correlation matrix, SPSS produces a "determinant" value. For this analysis the factors under consideration initially led to a determinant value less than 0.00001, which indicates the data may not be suitable for factor analysis. The correlation matrix was used to improve the list of questionnaire items. Those items that had a low number of significant correlations with the other items were removed.

7.3.6.1 *List of eliminated items*

- CQ14 (Time to school)
- CQ21 (Frequency of car journeys)
- CQ22 (Frequency of bus journeys)
- CQ27 (Years of bicycle independence)
- CQ33 (Time spent in organised activities at the weekend)
- CQ40d (Frequency of indoor destination e.g. swimming, shopping centre)
- CQ44 (Time spent watching television)

7.3.6.2 *Final factor analysis for child questionnaire*

An exploratory factor analysis was conducted on the remaining 25 items. The factor analysis was based on the 330 child questionnaires that had been recorded by the children

In the final iteration, using the 25 remaining items, principal component analysis was used to extract all factors with an Eigenvalue greater than 1, this resulted in 7 components being extracted from the 21 questionnaire items included in the factor analysis. A Varimax rotation was then used to simplify the factor loading.

The final components are shown below in Table 7-7, only coefficients with an absolute value above 0.5 have been retained.

Table 7-7: Rotated component matrix for child questionnaire factor analysis

	Component							
	1	2	3	4	5	6	7	8
Independence - Shopping Centres (43b)	.81							
Independence - Cinema (43c)	.80							
Independence - Sports facilities (43d)	.76							
Independence - Local shops (43a)	.67							
Independence - Park (43e)	.64							
Independence - organised activity (35)	.54							
Independence - allowed out alone (20)		.72						
Independence - Walking (29)		.70						
Years - visiting friend's house without adult (39)		.70						
Independence - Friend's houses (38)		.69						
Years - crossing main roads without adult (30)		.60						
Independence - to (16)			.88					
Independence - from school (19)			.83					
Time - organised activities (week) (32)				.83				
Frequency - organised activities (31)				.80				
Time - out of house (week) (42)					.71			
Time - out of house (weekend) (41)					.70			
Frequency - stay at home (40a)					-.57			
Frequency - bicycle journeys (26)						.78		
Frequency - walking journeys (28)						.54		
Frequency - outdoor destination (40c)						.52		
Frequency - friend's houses (40b)							.69	
Number of friend's houses (36 Binned)							.65	
Years - bus journeys (23)								.71
Years- living at current address (6)								

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

The first 7 factors were retained, and converted into separate entries in the child questionnaire database by recording the Anderson-Rubin scores for each of the factors.

The labels given to the factors in the questionnaire database are shown below in Table 7-8.

Table 7-8: Labels for the factors

Factor label	Questionnaire items
Independence – local destinations **(QF1)**	Independence - Shopping Centres (43b) Independence - Cinema (43c) Independence - Sports facilities (43d) Independence - Local shops (43a) Independence - Park (43e) Independence - organised activity (35)
Independence – allowed out walking alone **(QF2)**	Independence - allowed out alone (20) Independence - Walking (29) Years - visiting friend's house without adult (39) Independence - Friend's houses (38) Years - crossing main roads without adult (30)
Independence – school journey **(QF3)**	Independence - to (16) Independence - from school (19)
Time spent in organised activities **(QF4)**	Time - out of house (week) (42) Time - out of house (weekend) (41) Frequency - stay at home (40a)
Time spent out of the home **(QF5)**	Time - out of house (week) (42) Time - out of house (weekend) (41) Frequency - stay at home (40a)
Frequency of going out, walking and cycling **(QF6)**	Frequency - bicycle journeys (26) Frequency - walking journeys (28) Frequency - outdoor destination (40c)
Visiting friends **(QF7)**	Frequency - friend's houses (40b) Number of friend's houses (36)

7.4 Factor variation with age, sex and school

Figures 7-2 to 7-8 show how the mean values for each of the factors varies over the school years for boys and girls at both schools. Perhaps because of the missing data for Year 5, Burleigh Primary School shows a clear pattern for all the factors, except 'time spent out of home'.

7.4.1 'Independence' factors

The independence factors (Figures 7-2, 7-3 and 7-4) show a general increasing trend, with Burleigh Primary School pupils showing higher independence. Girls are generally more independent for local destinations, and boys are far more independent when it comes to walking and being allowed out alone.

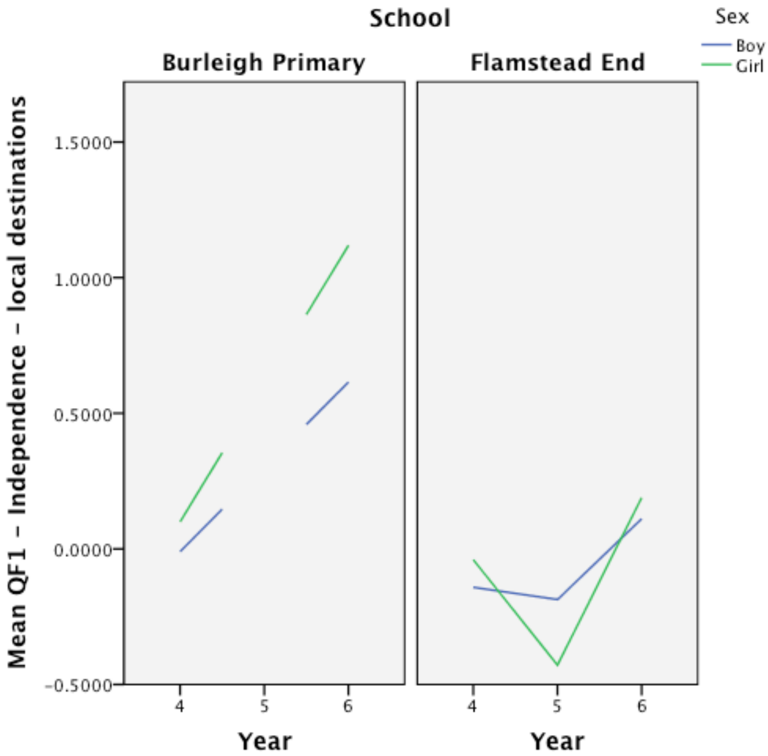


Figure 7-2: Independence for local destinations over the school years for boys and girls at both schools

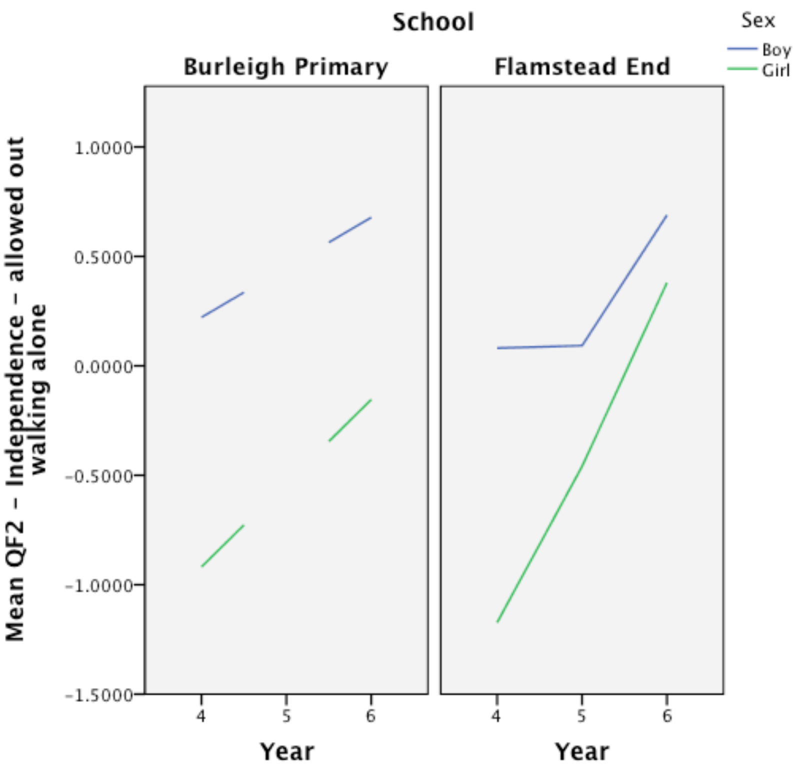


Figure 7-3: Independence—allowed out alone and walking alone over the school years for boys and girls at both schools

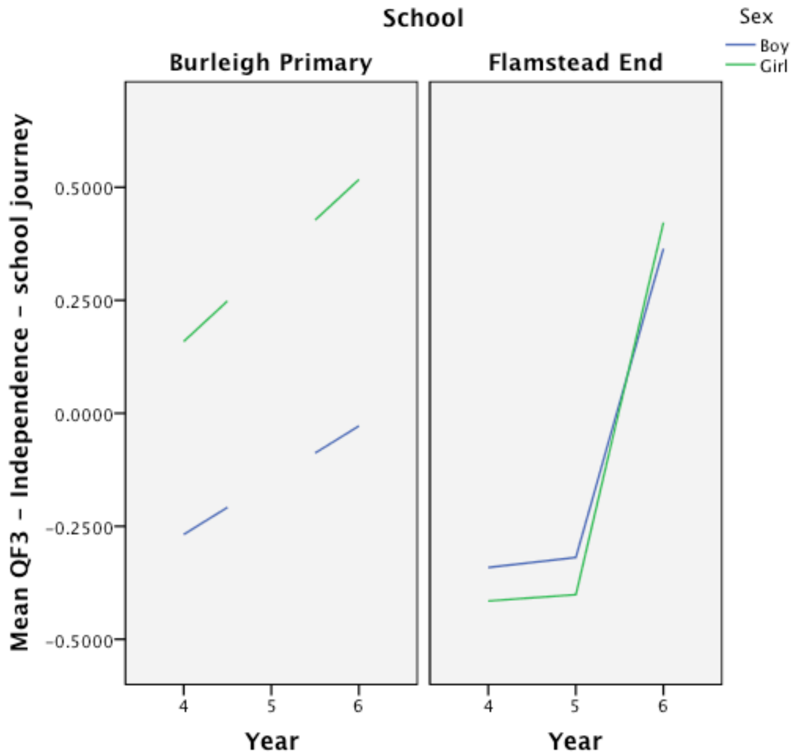


Figure 7-4: Independence on the school journey over the school years for boys and girls at both schools

7.4.2 ‘Time spent’ factors

There is no clear pattern shown by the factors for time spent in different activities (Figures 7-5 and 7-6). There is a general downward trend for time spent in organised activities, apart from the Year 6 boys at Flamstead End Primary School (Figure 7-5). There is no shared trend for any of the groups when it comes to time spent out of the home (Figure 7-6).

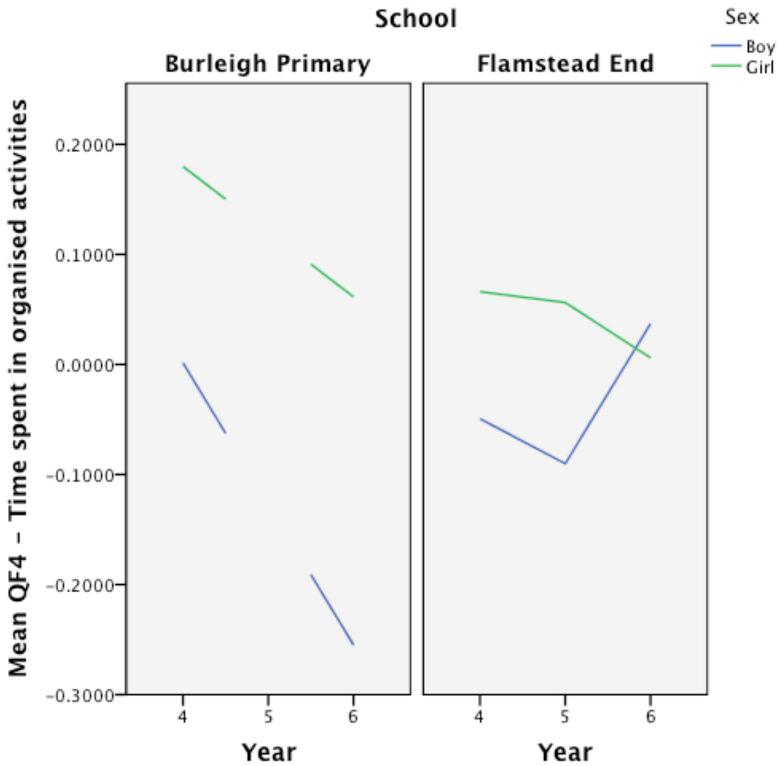


Figure 7-5: Time spent in organised activities over the school years for boys and girls at both schools

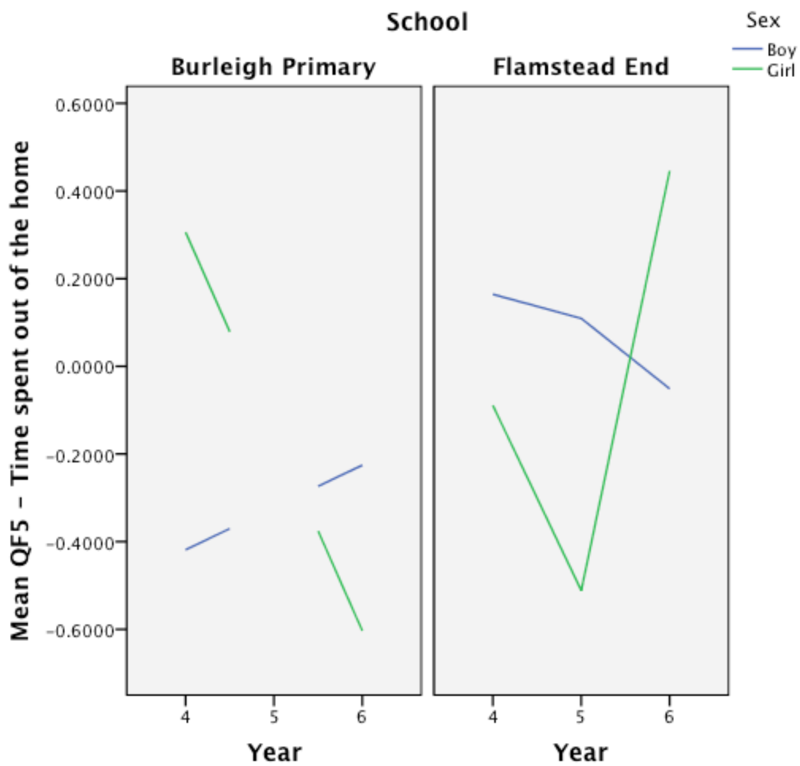


Figure 7-6: Time spent out of the home over the school years for boys and girls at both schools

7.4.3 'Frequency' factors

The two factors dealing with frequency (Figures 7-7 and 7-8) do show reasonably clear trends, generally up for the frequency of going out, and down for the frequency of visiting friend's houses.

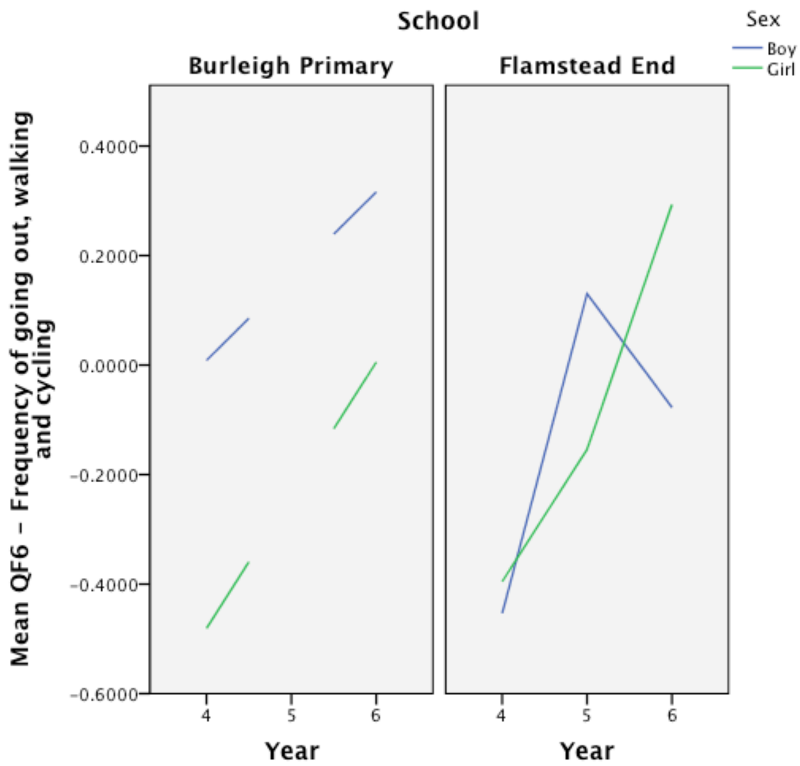


Figure 7-7: Frequency of going out, walking and cycling over the school years for boys and girls at both schools

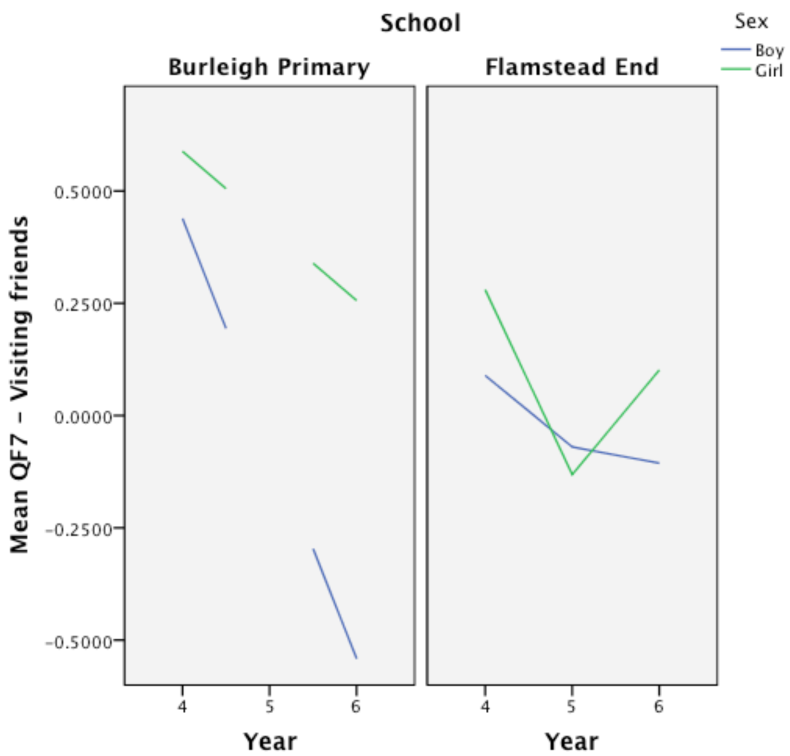


Figure 7-8: Visiting friends over the school years for boys and girls at both schools

7.5 Regression analysis of map score using the questionnaire factors

Multiple regression analysis was used to investigate the contribution of the questionnaire factors on the accuracy of the children's sketch maps. The regression analysis used distortion index (DI) weighted by element count as the dependent variable. DI is a measure produced from the bidimensional regression of the children's area sketch maps, and is described in Chapter 6. The questionnaire factors described above (see Table 7-8 in this chapter) were included as the explanatory factors. Four different regression equations have been calculated, one for each combination of child's sex and school:

Boys at Burleigh Primary	$R^2_{adj} = 0.53$; $F_{(8, 68)} = 11.90$, $p < 0.0005$
Girls at Burleigh Primary	$R^2_{adj} = 0.60$; $F_{(8, 139)} = 28.39$, $p < 0.0005$
Boys at Flamstead End	$R^2_{adj} = 0.26$; $F_{(8, 437)} = 20.60$, $p < 0.0005$
Girls at Flamstead End	$R^2_{adj} = 0.12$; $F_{(8, 506)} = 9.5$, $p < 0.0005$

All the regression equations were highly significant. The fit, as indicated by the adjusted R^2 values, differed between the two schools. Regression analyses for Burleigh Primary produced a much better fit than analyses for Flamstead End.

Table 7-9, below, shows the Beta values for the explanatory factors included in the regression analysis. The Beta values indicate the relative contribution of each of the included factors in the regression equation. A factor with a higher value contributes more to explaining the variance observed in the dependent variable.

Table 7-9: Beta values for a regression using questionnaire factors

	Burleigh Primary		Flamstead End	
	Boys	**Girls**	**Boys**	**Girls**
School year	0.11	-1.30***	-0.38***	-0.12
Independence – local destinations	0.13	0.70***	-0.02	0.16**
Independence – going out and seeing friends	0.10	0.50***	-0.07	0.02
Independence – school travel	0.49***	0.39***	0.09	0.00
Time spent in organised activities	-0.37***	0.25***	-0.22***	-0.14**
Time spent out of the home	-0.80***	0.14*	0.08	0.23***
7.5.1.1.1.1 **Frequency of going out, walking and cycling**	0.26*	-0.03	0.32***	0.18 ***
Visiting friends	1.18***	-0.14	0.30***	0.05

* Significant at $p < 0.05$; ** Significant at $p < 0.005$; *** Significant at $p < 0.0005$

The most obvious result from the above is that many of the factors that have a significant impact on the DI score for the children's maps, acting to increase the level of distortion.

It is also apparent that there is no clear pattern about which questionnaire factors increase or decrease distortion in the children's maps. Some factors seem to apply only to one school or the other; "Independence on the school journey", for instance, increases the value for DI for boys and girls at Burleigh Primary, but has no significant effect for children at Flamstead End. There are other factors that seem to only apply to one sex; "Visiting friends", for instance, increases the DI score for boys, but not for girls. Even for factors that are significant for all groups do not show a clear pattern; "Time spent in organised activities" is significant for all groups, reducing DI for all children, except for girls at Burleigh Primary.

The findings from the regression analysis appear to suggest that different factors will influence the accuracy of a child's representation, depending on whether they are male or female, and which school they attend.

7.6 Chapter summary

This chapter dealt with the children's questionnaire, which was developed with input from the author as part of the CAPABLE research project. The questionnaire was designed to gather basic identifying information about he children and information about their travel and activities. Questionnaire items included questions about journeys to a range of destinations in the local environment, including journeys to and from school. Children were also asked about who accompanied them on a range of journeys, and from what age they were allowed to take part in different independent behaviours.

Exploratory factor analysis was employed as a data reduction technique, investigating the possibility that responses could be described by a smaller number of factors. As a result of the analysis seven factors were produced. In general, factors dealing with independence increase with age, with higher values for children at Burleigh Primary. There seems to be no clear pattern for the factors describing 'time spent'. Frequency of going out to walk and cycle shows a general upward trend, and frequency of visiting friend's houses show a general downward trend.

A regression analysis that used the factors derived from the questionnaire revealed an unclear picture. It appears that the questionnaire factors have a different influence on the level of distortion observed in a child's map depending on which school they attend and whether they are a boy or a girl.

8 Comparing sketch maps with the real world

8.1 Comparing sketched distances with real world distance

A linear regression was conducted using the distance values for both the real world and sketch map data. In both cases distances are calculated from the school attended by the child. Real world data is taken from Ordnance Survey map data and is measured in metres. The sketch map data is taken from scanned images of the children's hand drawn maps, the units for the sketch map data are also metres, using a scaling factor based on the size of the school on the children's worksheets (see Chapter 6). Where the landmark has been recorded on more than one sketch map, the value for sketch map distance is the mean of the distances from all the maps it appears in.

8.2 Position of the sketched landmarks

Figure 8-1, below shows the positions of all the identifiable points recorded by the children in their sketch maps.

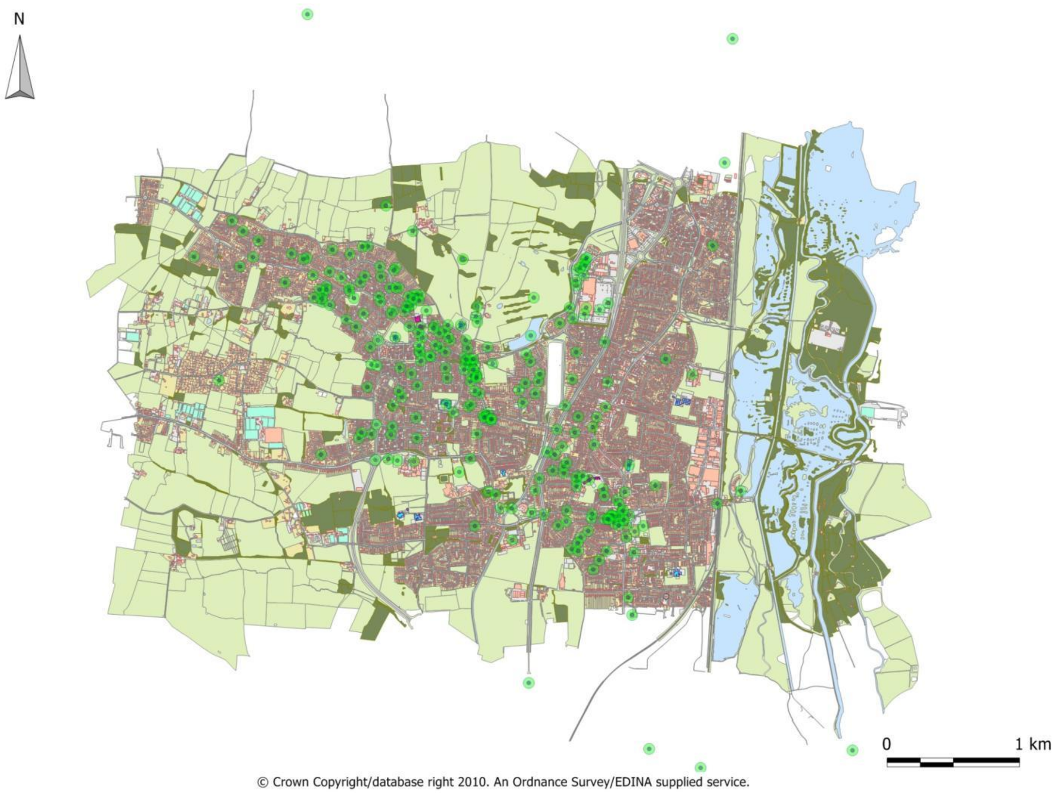


Figure 8-1: Position of all the landmarks recorded by children in the Cheshunt sample

In some cases a position in the real world has been represented by more than one child, the bar chart below in Figure 8-2 shows the number of occurrences of each of the 264 different elements in the dataset (the unique identification numbers used for the landmarks in the database run from 1–275).

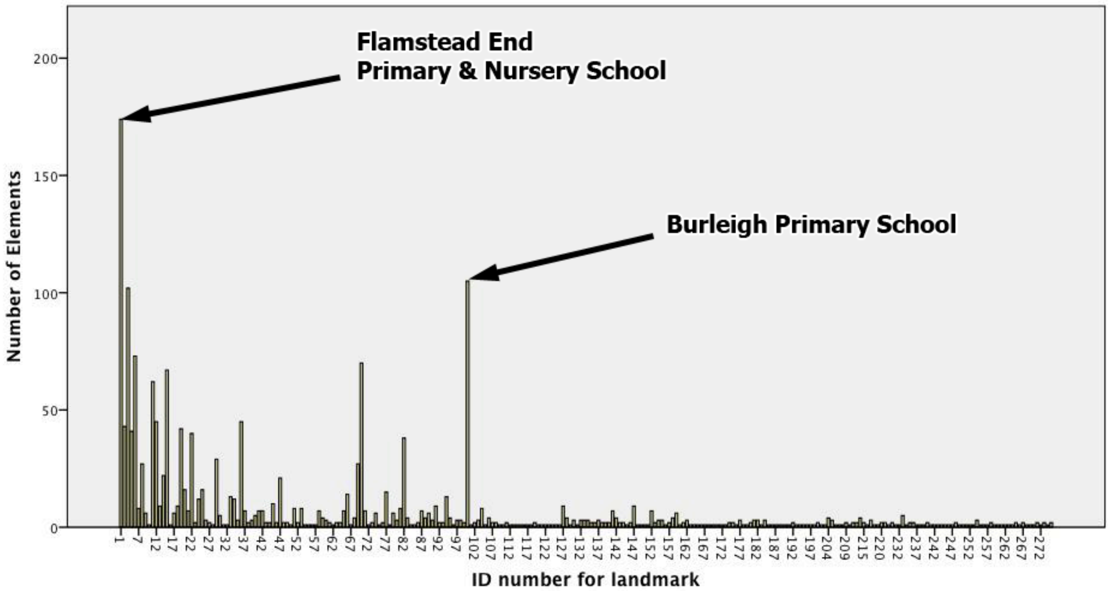


Figure 8-2: Number of occurrences of each of the distinct Cheshunt landmarks

Figure 8-3, shown below, is a graph showing the distribution of the number of mentions of all the landmarks in the dataset. Both schools have been removed and the landmarks have been reordered to give a clearer view of the distribution.

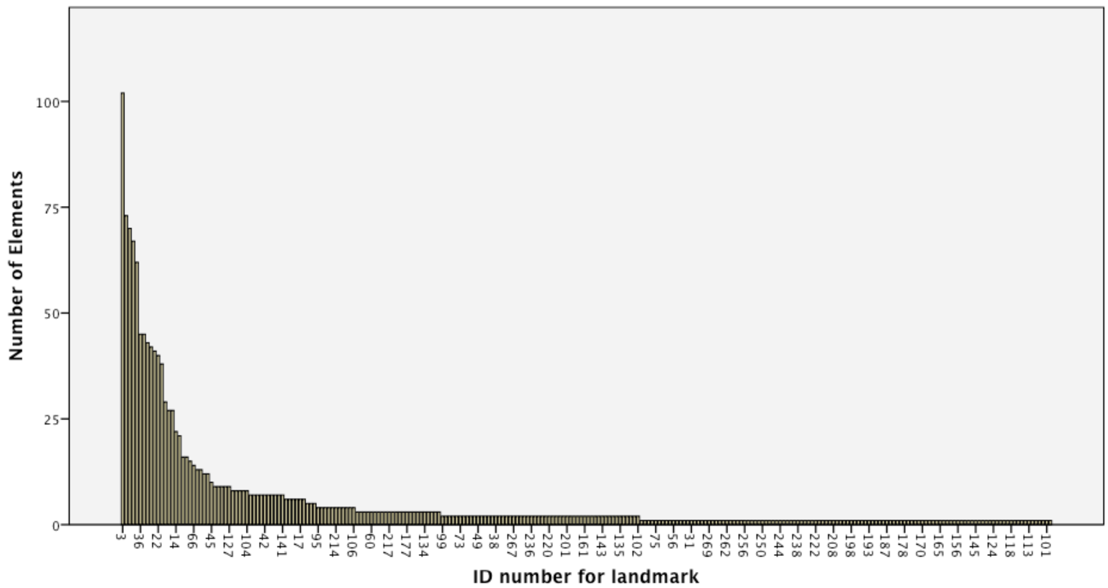


Figure 8-3: Distribution of the number of mentions of the distinct landmarks in the Cheshunt sample

8.3 Landmarks included by more than one child

Before analysing comparing the real-world and sketched distance, all instances where the sketch map or real world distance was zero (both origin schools) were removed. Also removed was one very distant point, a postcode recorded in one of the children's questionnaires that was over 5km away from the school. Removing these points leaves 261 landmarks. Figure 8-4, below, shows a scatterplot of sketched distance against real world distance. In Figure 8-4 blue markers are used to show landmarks that have been mentioned by only one child, while green markers are used to show landmarks that have been included in maps from more than one child.

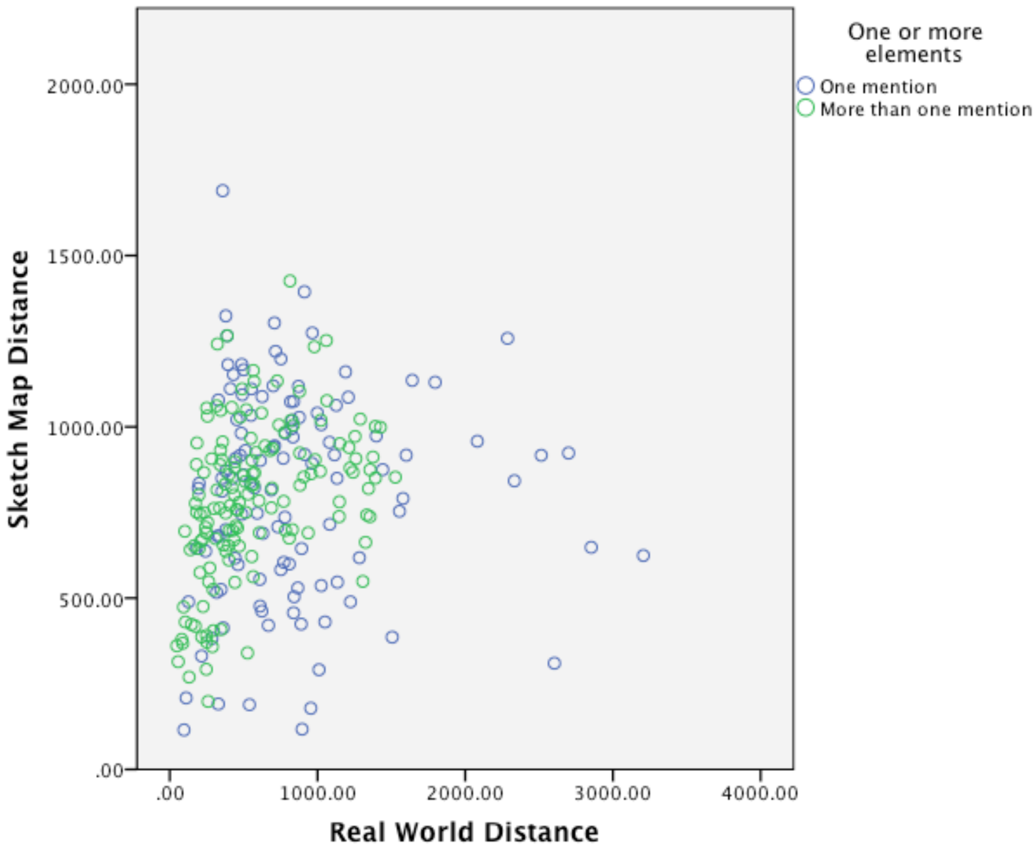


Figure 8-4: Distance in area sketch map against real world distance for the landmark – blue markers represent landmarks mentioned by one child, green markers show those mentioned by more than one child.

The pattern for the landmarks that have been recorded more than once appears to be tighter than the pattern for those that only appear in one child's map. This is reflected in the difference between the correlation coefficients for the full set: $r(259) = 0.19$, $p = 0.002$, and for a restricted set, which includes only those elements that are mentioned by more than one child: $r(144) = 0.42$, $p < 0.0005$ (both correlations use Pearson's r and report two-tailed significance values). Both correlation results indicate significant positive correlations, but the restricted set represents a much stronger correlation than the full set.

Both correlations suggest that, as one might expect, children represent close elements as close and far elements as further away. Overall the children appear to be representing the order of the landmarks correctly as they move away from the school. The pattern of the points suggests that this might not be a linear relationship, as the points that make up the restricted dataset seem to follow a curve.

8.4 Logarithmic distortion in sketched element distance

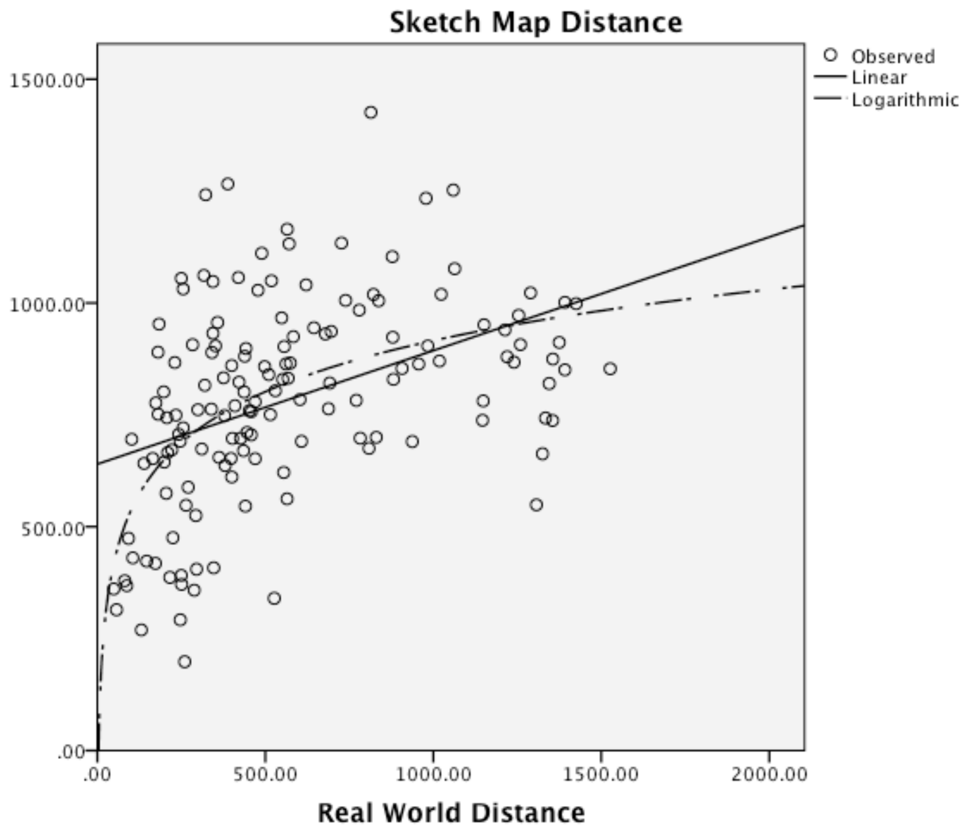


Figure 8-5: Comparing linear and logarithmic fits for the distance data

The graph shown in Figure 8-5 above compares regression lines for the real world and sketch mapped distances. The logarithmic fit appears to give a better fit to the data, and this is supported by looking at correlation results using transformed values of real world distance. The values for real world distance were transformed by taking the natural log of the real world distances, the correlation coefficient for this new measure:

$r(144) = 0.53, p < 0.0005$, represents a stronger correlation than the previous untransformed measure.

At least two explanations can be suggested for this finding, and both may be playing a role here. The first explanation is the simplest explanation, and it is that the instructions or the materials supplied the area sketch mapping task were not sufficient. The children may for instance have had difficulty in including all the relevant landmarks within the confines of an A4 worksheet. The size of the worksheet was chosen for practical purposes, which included the space available for children to work and the ease of producing extra copies. The less prosaic reason is that the result reflects part of the cognitive transformations that occur as information about the environment is coded into spatial representations, or information about the environment is recalled from the spatial representation. It is possible that the distortion of metric distance is occurring as the information is read back from the child's cognitive map. Drawing the map requires recalling information from the child's cognitive map to show the location of landmarks relative to the school, and to each other, it would appear that the exact scaling is less important than the relative positions of the landmarks. I would suggest that the relationship seen between the real world and area sketch map distances is a combination of the way in which distance information in a cognitive map can be encoded in categorical and topological terms, rather than with exact coordinates, and the limits of imposed by the task. As well as providing a bounded space in which to draw the map, the instructions did not explicitly ask for accurately scaled dimensions or distances, so the children completed the task of including "as many landmarks and places as you can remember near your school" without imposing extra unstated requirements.

8.5 Using classification of sketch map style

The children's sketch maps were analysed to assess the style used in the overall representation. The differences in the ways that children represent the information in their maps has been used by researchers to make judgements about their cartographic competence (Matthews, 1992). The following analysis uses a scheme that divides the children's sketch maps into one of three categories, it is suggested that the categories are based not only on the representational style but also the ability of the child to translate space into a two-dimensional form (Matthews, 1984), this process is also referred to as topological transformation. Although the scheme consists of three categories, the second category is reserved for maps that fall between the first and the last categories (referred to as Grade I and Grade III)

8.5.1 Grade I – Pictorial Maps

These are maps that represent the environment as a series of pictures.

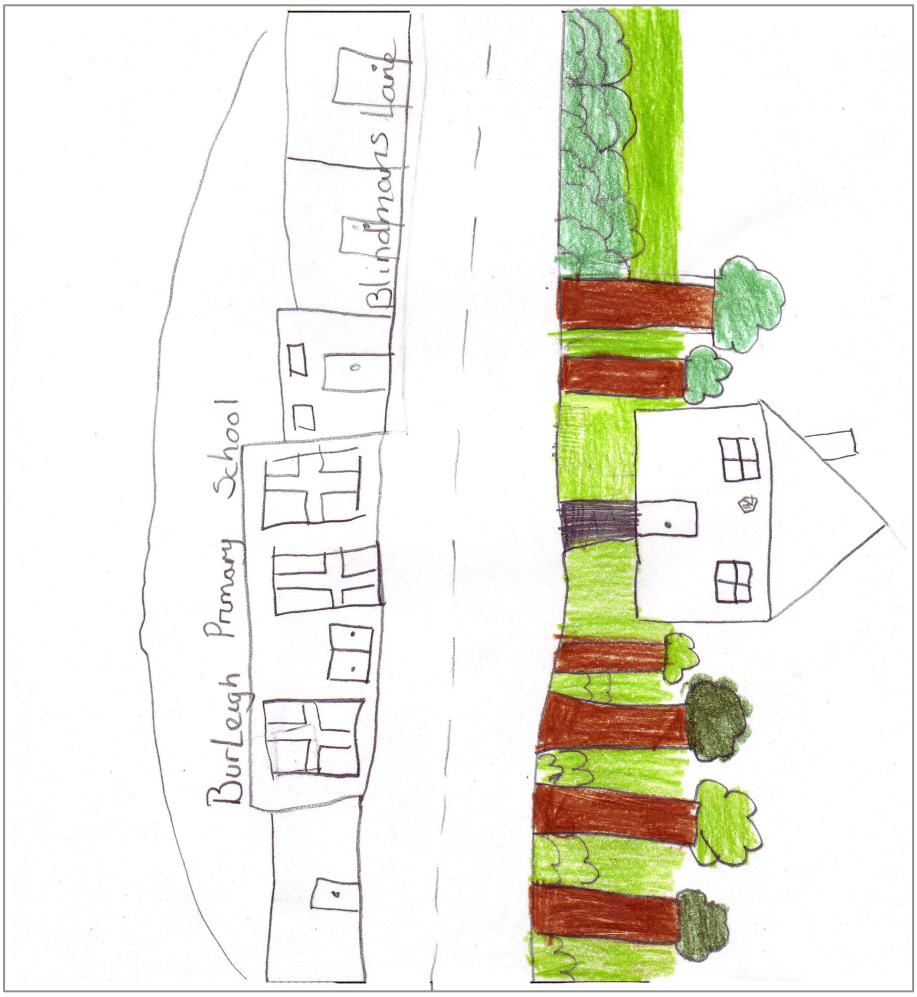


Figure 8-6: A route map that was classified as Grade I or Pictorial (BP4-009)

One of the most notable aspects of these maps is that the buildings are often represented as they might be seen from street level. Matthews states that this style shows that the child has not learned the skills required to rotate a view to produce the aerial view that is standard in many maps (Matthews, 1992).

Figure 8-6 above shows a sketch map that has been classified as Grade I (Pictorial) because of the extensive use of picture type elements to represent buildings and other environmental features. The map in Figure 8-6 was drawn by a child in Year 4 at Burleigh Primary School. This category includes some of the most attractive maps, as they often include details like windows and doors that would be lost in the transformation to an aerial view, and some of the maps also include extensive colouring in of the elements.

8.5.2 Grade II – Plan-Pictorial Maps

These maps use a mixture of the representational styles used in Grade I and Grade III maps, so in these maps some of the features in the environment are represented by symbols while others are left unrotated in their 'viewed from street level' style.

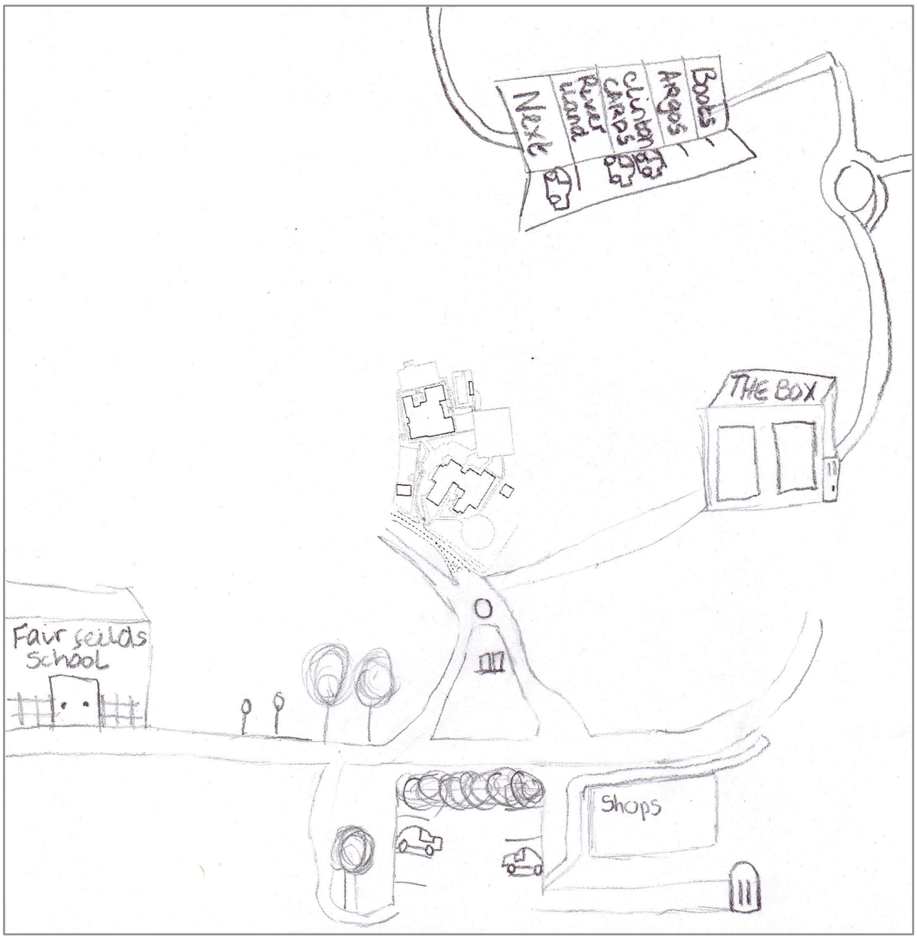


Figure 8-7: A sketch map that has been classified as Grade II as it mixes Grade III (plan) and Grade I (pictorial) representational styles (FE5-011)

Figure 8-7, shown above, gives an example of a map from a child in Year 5 at Flamstead End Primary School that mixes the representational styles from Grade I and Grade III.

8.5.3 Grade III – Plan Maps

The third category is for maps that display the child's ability to take the information stored about the environment and represent that information in the form of an aerial map. This style of representation most closely represents a standard cartographic map, and has been taken to show that the child has performed a series of complex mental transformation on the stored representation of the environment (Gerber, 1981), including an imaginative reorientation of the features.

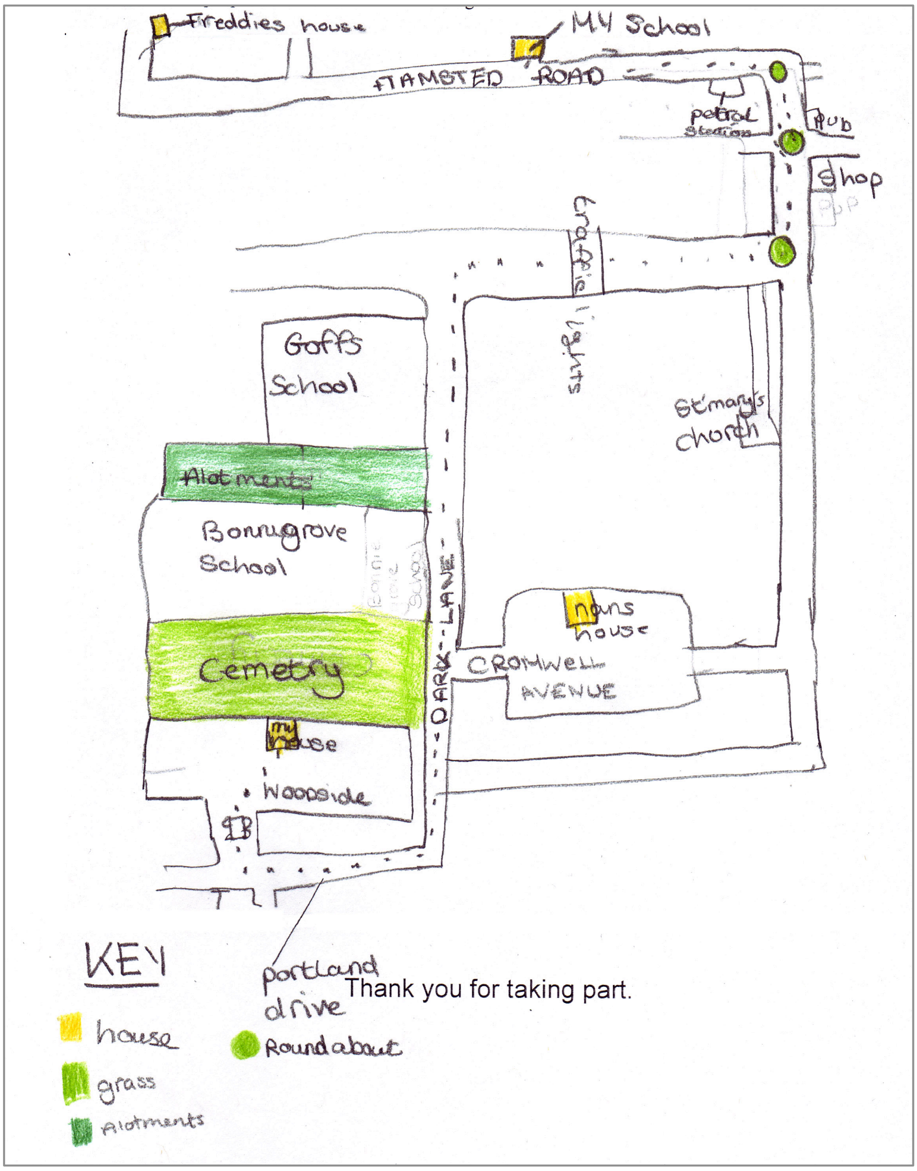


Figure 8-8: Sketch map classified as Grade III or plan (FE5-008)

Figure 8-8 above shows an example of a Grade III, or plan, map. The child has represented buildings and areas as simple rectangles, which I have assumed represent an outline of the building as viewed from above, and extensive labelling has been use to differentiate the different elements.

8.6 Note on sample sizes for the sketch map tasks

Because the children sometimes completed the different mapping tasks, route map and area map, on different days, there are cases where only one type of map is present.

Cases where the child did not produce a particular kind of map, either area or route, have been excluded from the analysis for that map type and this is reflected in the differences in sample sizes.

The following section will deal with the broad differences in cartographic competence, or sketch map style.

8.7 Route maps and area maps included in the analysis of style

278 children were involved in the sketch mapping exercises, 271 (97%) of children returned a route map that could be assessed for cartographic style, and 263 (95%) of children returned an area sketch that could be assessed for style.

8.8 Rating the sketch maps

A weakness of this approach is that the ratings of the sketch maps rely in large part on the assessment of one rater, the experimenter. The maps were assessed by a second rater, and her assessments were considered, and led to some cases being reassigned, however, the final decision was made by the experimenter. In both cases the ratings were based on scans of the maps which were referenced by a filename that only made it clear which class (school year and school) the child came from. The ratings were done some time after the initial data collection, so it is unlikely that any information about the child's sex, the mode they used to travel to school, or any other details recorded during the fieldwork would have been remembered. A more robust methodology could be used to reduce the possibility of bias.

8.9 Broad differences between the children's sketch maps.

8.9.1 Differences in sketch map style between boys and girls

Figure 8-9, below, shows the percentage of route maps which fall into each of the three style categories, after removing all the cases where no map was recorded. It can be seen that slightly more of the maps produced by the boys can be categorised as plan (Grade III), the most advanced map type. A chi-square test reveals that this small difference is not significant χ^2 (2, N = 271) = 0.65, p = 0.724.

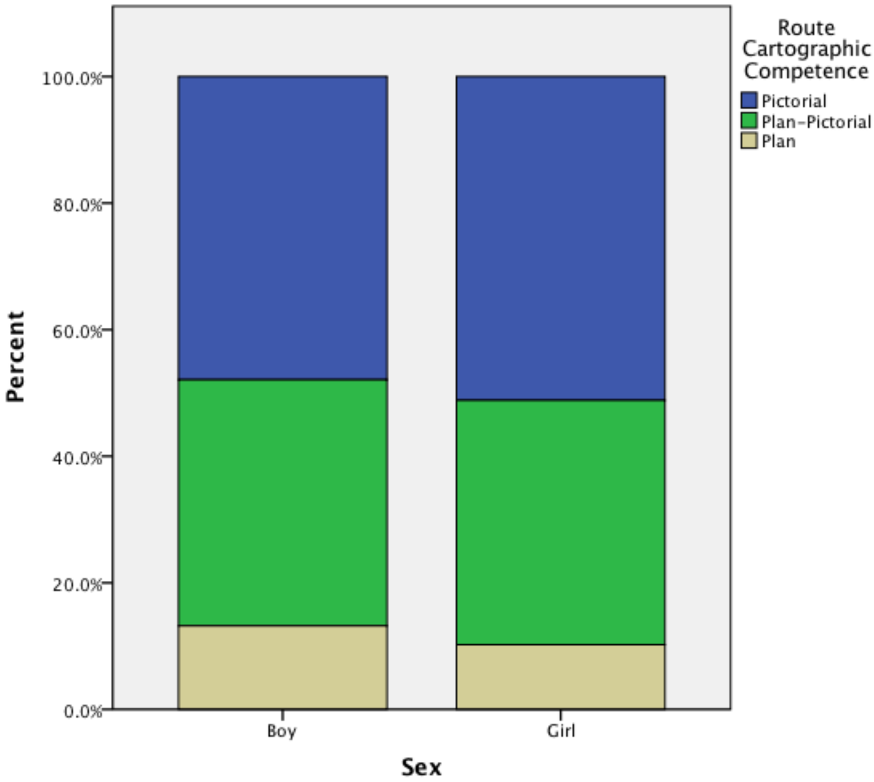


Figure 8-9: Difference between the cartographic styles for route sketch maps produced by boys and girls

The situation for the area sketch maps appears to be different. Inspecting Figure 8-10, which shows differences between in area sketch maps styles between boys and girls at both schools, reveals that there appears to be a greater proportion of plan and pictorial style maps produced by boys in the sample. Boys, it seems, are producing more of the most and the least complex maps. A chi-square test reveals that the relationship between area sketch map cartographic competence and sex is significant, χ^2 (2, N = 263) = 7.15, p = 0.028.

The difference is probably best characterised by seeing it as a difference in the proportion of the plan-pictorial style of map, boys seemed to have produced fewer of these, falling more easily into the most and least competent categories.

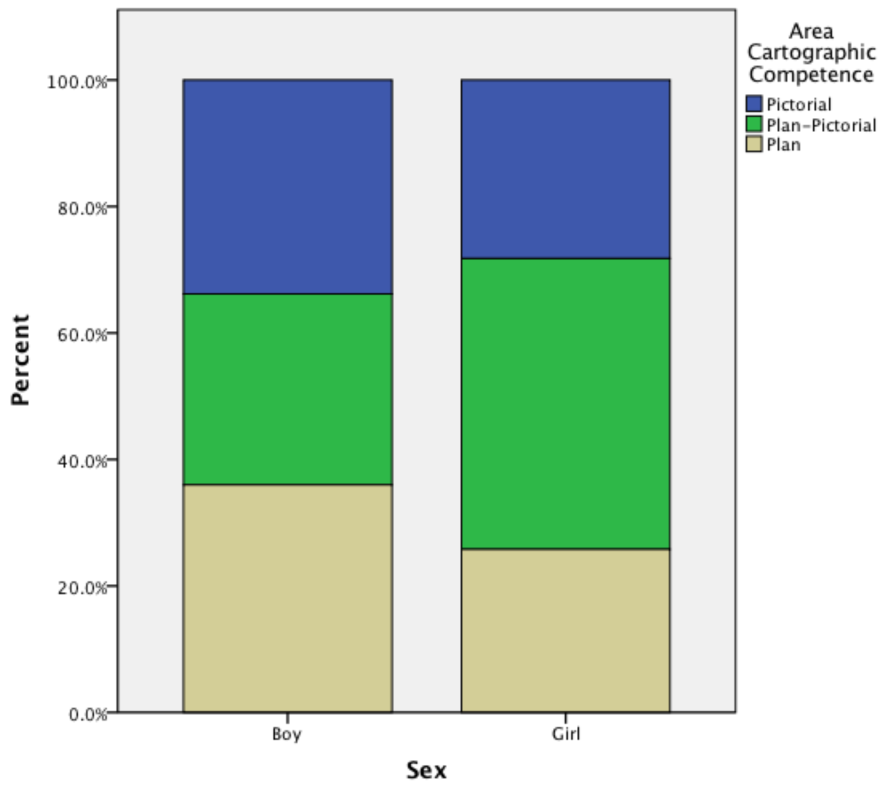


Figure 8-10: Difference between the cartographic styles for area sketch maps produced by boys and girls

There is no clear difference between cartographic competence between boys and girls when considering the area maps.

It is likely that the differences in the proportions of the different styles of sketch maps will also be related to the age of the children.

8.9.2 Relationship between year group and cartographic competence

In contrast to the mixed picture revealed when the sexes are compared, there is a very clear pattern revealed when the different age groups are compared. The graphs below, Figures 8-11 (for route maps) and 8-12 (for area maps), show the clear progression in cartographic competence that is associated with increasing year group.

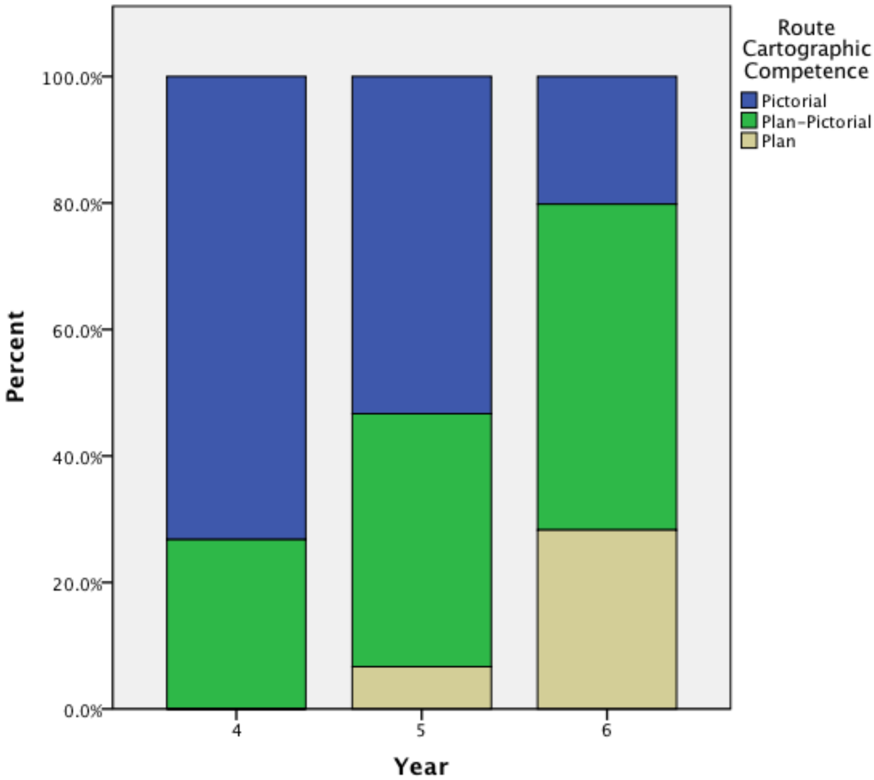


Figure 8-11: Difference between the cartographic styles for route sketch maps produced by different age groups

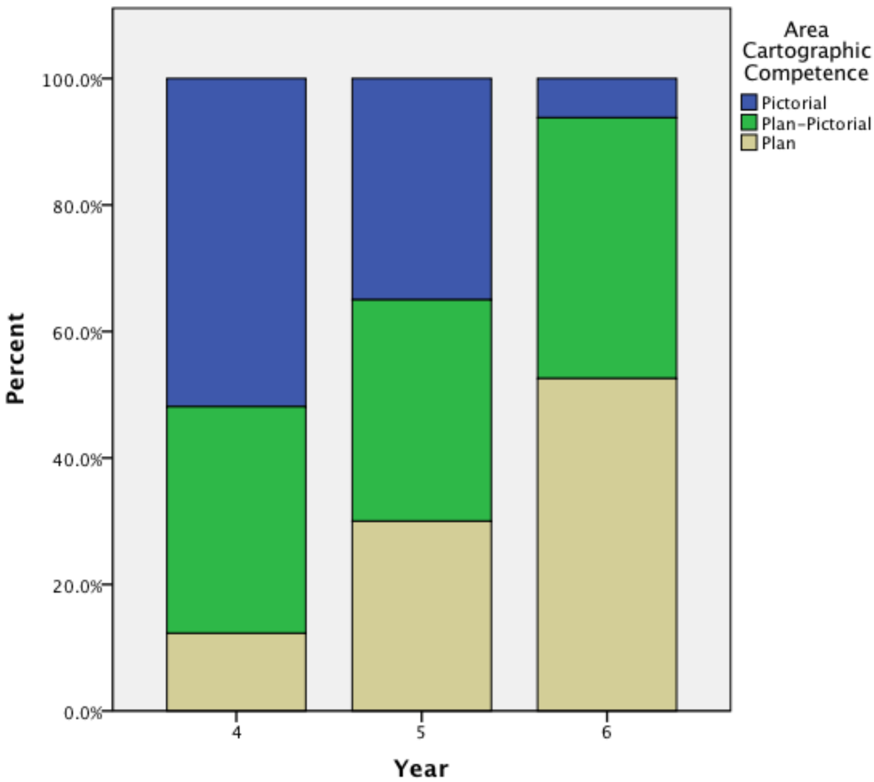


Figure 8-12: Difference between the cartographic styles for area sketch maps produced by different age groups

As the children progress to later classes, fewer of them produce maps that can be classified as pictorial style, and more produce maps that fall into the plan category. The progression is clear for both route and area maps. In both cases a chi-square test reveals a significant relationship χ^2 (4, N = 271) = 75.75, $p < 0.0005$, for the route maps, and χ^2 (4, N = 263) = 61.26, $p < 0.0005$, for the route maps.

8.9.3 Differences in cartographic competence between the two schools

When assessing the differences in sketch map style, it must be remembered that the sketch mapping task was not completed by children in all years at both schools: children in Year 5 at Burleigh Primary did not complete the sketch mapping tasks. The graphs in Figure 8-13 and Figure 8-14, below, show the differences between the proportions of children who fall into each category for cartographic competence based on their route and area sketch maps, respectively.

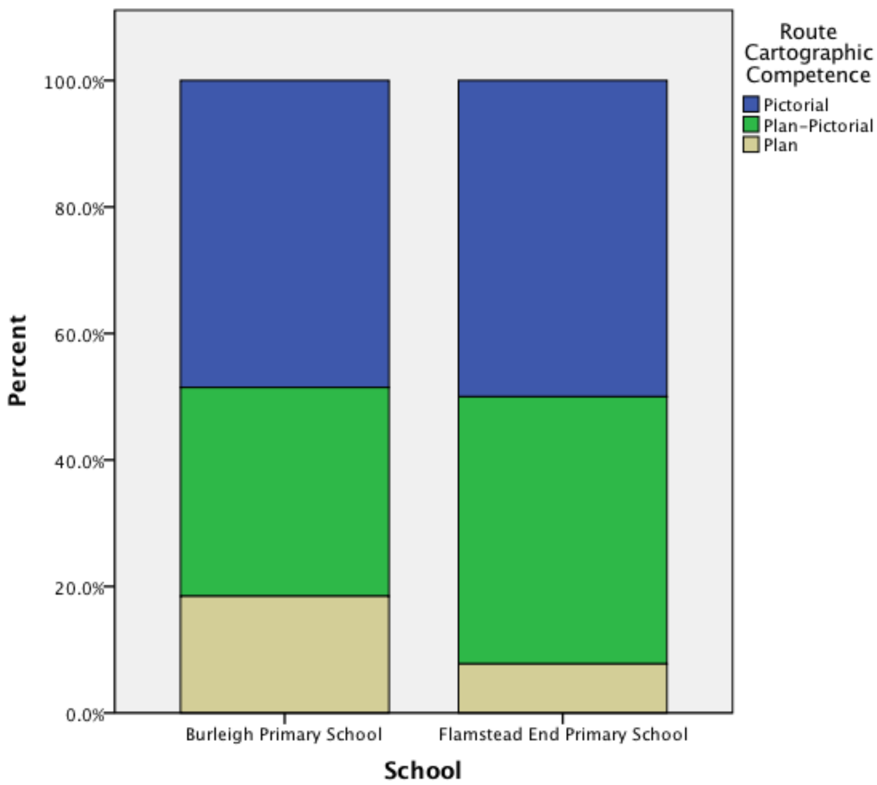


Figure 8-13: Differences between the two schools in cartographic competence for route sketch maps

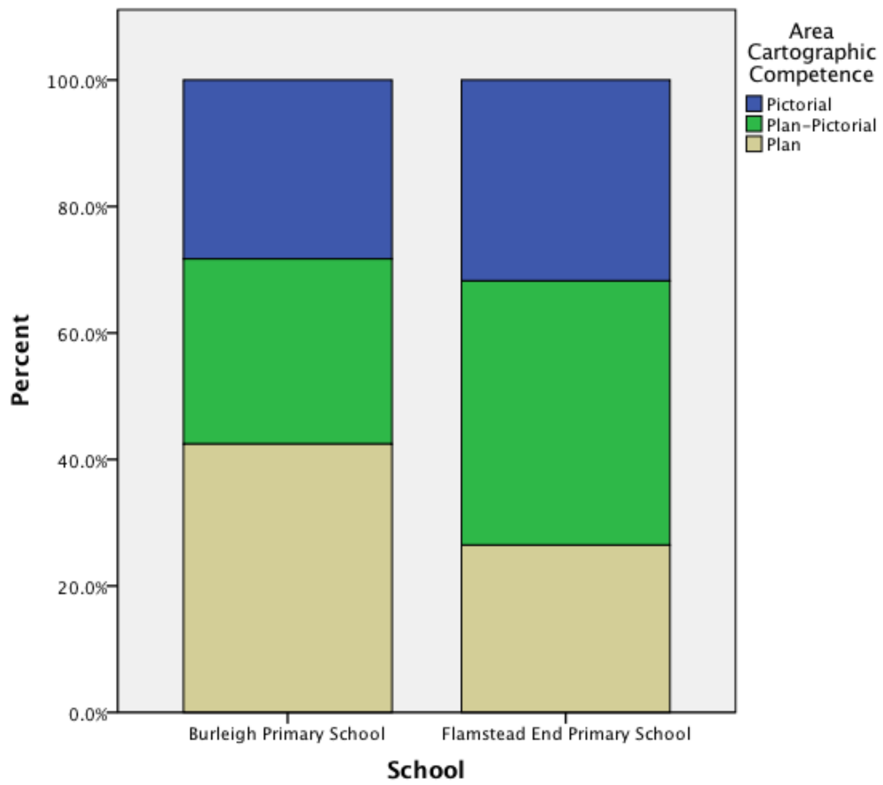


Figure 8-14: Graphs showing the proportions of children's area maps that fall into each of the cartographic competence classifications.

In the case of both of the graphs, excluding children from Year 5, to account for missing data at Burleigh Primary School, leads to changes that are so small that they are not immediately apparent. Table 8-1, below shows the percentage of route maps in each category when the data from Year 5 children is included and excluded, it can be seen that while the number of children in each group changes noticeably, the percentage in each group changes only subtly.

Table 8-1: Comparing the percentage of route maps in each category when the data from Year 5 children is included and excluded

	Burleigh Primary - No Year 5 data	Flamstead End - including Year 5	Flamstead End - excluding Year 5
Pictorial	50 (48.5%)	84 (50%)	52 (48.1%)
Plan-Pictorial	34 (33%)	71 (42.3%)	47 (43.5%)
Plan	19 (18.4%)	13 (7.7%)	9 (8.3%)
All style	103 (100%)	168 (100%)	108 (100%)

A very similar pattern is seen with the results for the area sketch maps, see Table 8-2, below.

Table 8-2: Comparing the percentage of area maps in each category when the data from Year 5 children is included and excluded

	Burleigh Primary - No Year 5 data	Flamstead End - including Year 5	Flamstead End - excluding Year 5
Pictorial	28 (28.3%)	54 (31.8%)	33 (31.4%)
Plan-Pictorial	29 (29.3%)	71 (41.8%)	49 (46.7%)
Plan	42 (42.4%)	45 (26.5%)	23 (21.9%)
All style	103 (100%)	170 (100%)	108 (100%)

There are, however, differences in the proportions of maps in each category between the two schools. Chi-square tests (excluding children in Year 5) reveal that the differences are significant for the area sketch maps χ^2 (2, N = 203) = 10.37, p = 0.006; but not for the route sketch maps, χ^2 (2, N = 211) = 5.58, p = 0.061.

In the previous comparison of sketch map style across age groups we saw a significant difference for both the area maps and the route maps. So, it is interesting to see that when we make the comparison between schools, the differences are significant only if we consider the area maps, and not the route maps. This might suggest that there is some difference in the environment surrounding the school, the thing that is represented in the area sketch mapping task, and it is this difference in environment that is leading to this difference.

8.10 Cartographic competence: Interactions

The contributions of the factors considered in the section above can be considered by using a 2*2*3 Analysis of Variance (ANOVA) with 3 between subjects factors representing the sex of the child (2 level), the school that they attend (2 level) and their school year (3 level). Two ANOVA models will be considered, the first will use the assessment of the route sketch mapping task as the dependent variable, the second will take the assessments of the route sketch mapping task as the dependent variable. In both cases, the children's results will be treated as if they are scores between 1 and 3, where 1 represents a pictorial map (Grade I), 2 a plan-pictorial map (Grade II) and 3 represents a plan style map (Grade III).

The results of these comparisons should be treated with some caution as the dependent variable is at the ordinal rather than the scale level, so the data does not meet the strict criteria for the use of the ANOVA test. However, it was felt that using the ANOVA model does allow some insight into the contribution and interactions of the different factors.

8.10.1 Route map cartographic style ANOVA results

The graph in Figure 8-15 shows the overall average route map style score for children at both the Cheshunt primary schools, for all three school years under consideration. The blue points in Figure 8-16 show the average area map scores for children at Burleigh Primary School, and the green points show the average scores for the children at Flamstead End Primary School

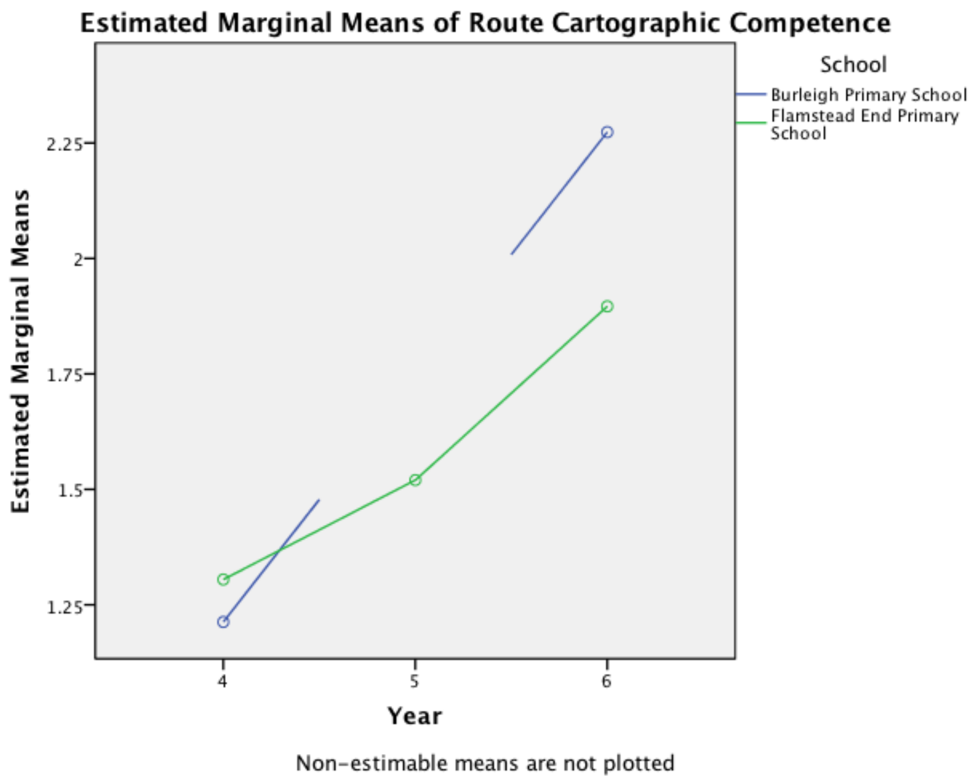


Figure 8-15: Average route map style scores by school and school year

It can be seen that in Year 4 children in Burleigh Primary School have slightly lower average route map scores than children in Flamstead End, by the time the children are in Year 6, their positions have reversed, with children at Burleigh Primary School outperforming children at Flamstead End Primary School by a much larger margin. The main effect for school is not significant, $F_{(1,\ 261)} = 3.14$, $p = 0.77$ However, the interaction between school year and school, $F_{(1, 261)} = 8.5$, $p = 0.004$ is significant.

The interaction may indicate that there is something about the area around Burleigh Primary school that plays a greater role in cognitive development as they grow up.

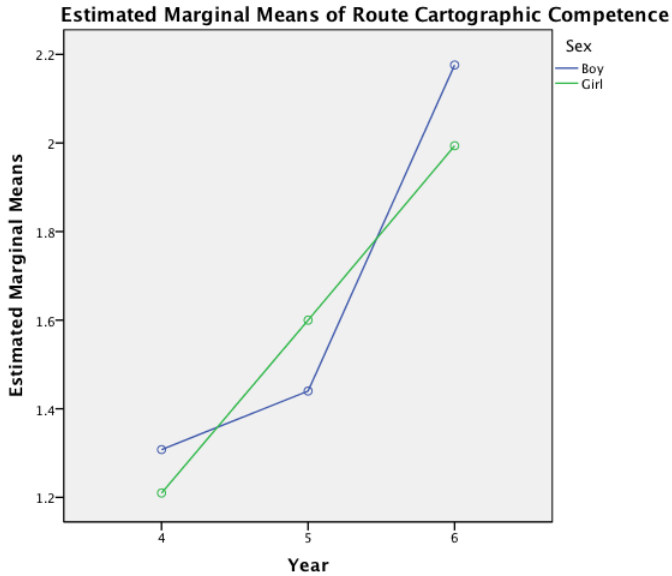


Figure 8-16: Average route map style scores by sex and school year

The graph shown above in Figure 8-16 shows the overall average route map style score for boys and girls over the three school years under consideration. The increase of average score as school year increases is, once again, apparent. The main effect for school year is highly significant $F_{(2, 261)} = 52.96$, $p < 0.0005$. The graph also shows separate lines for boys and girls. After examining the graph it is no surprise that there is no significant main effect of sex, $F_{(1, 261)} = 0.85$, $p = 0.357$, nor is there any interaction between sex and school year $F_{(1, 261)} = 0.39$, $p = 0.303$.

The remaining interactions, sex*school, and sex*year*school, are not significant, $F_{(1, 261)} = 0.09$, $p= 0.771$ and $F_{(1, 261)} = 1$, $p = 0.318$, respectively.

8.10.2 Area map cartographic style ANOVA results

The graph in Figure 8-17 shows the overall average area map style score for children at both the primary schools across the three school years under consideration.

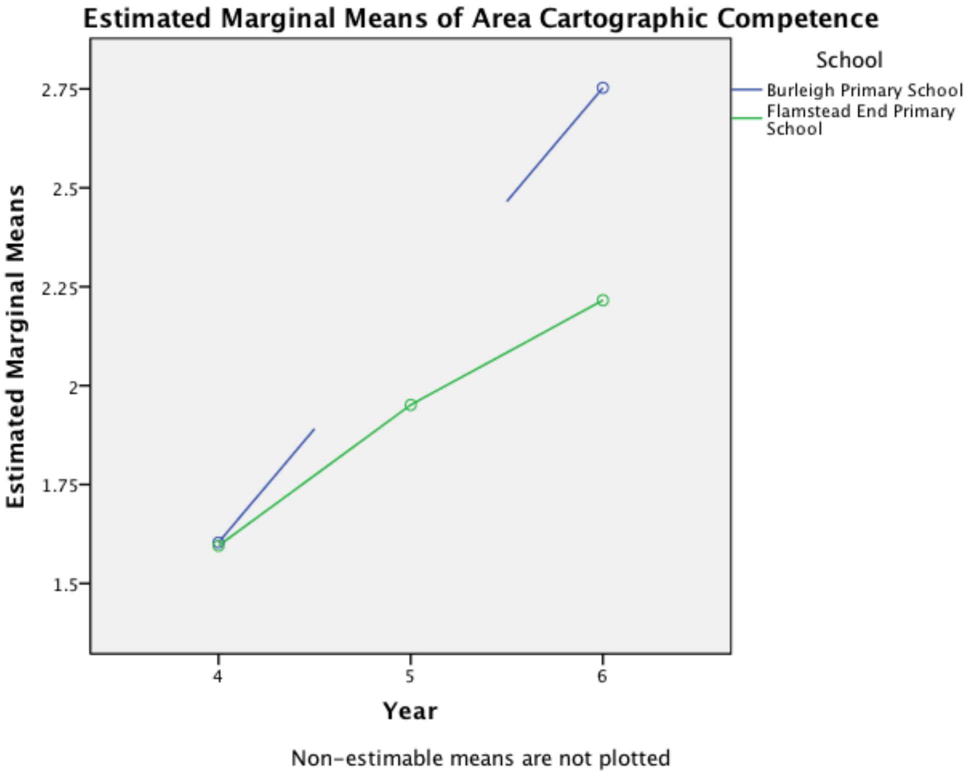


Figure 8-17: Average area map style scores by school and school year

It can be seen that while children at both schools in year 4 perform at a similar level, by the time the children reach Year 6, the performance on the Area Sketch Mapping task has diverged, with children at Burleigh Primary showing higher average scores. The main effect for school is significant, $F_{(1, 253)} = 3.69$, $p = 0.005$. As is the interaction, between school year and school, characterised by the increasing divergence between schools as school year increases, $F_{(1, 253)} = 3.47$, $p = 0.007$.

This result amplifies the finding from the route map analysis: that there is a clear interaction between the school attended and the child's school year which leads to children in Year 6 at Burleigh Primary producing more maps that can be classified as Grade III (plan). The children at the two schools seem to be on different gradients for the development of cartographic competence.

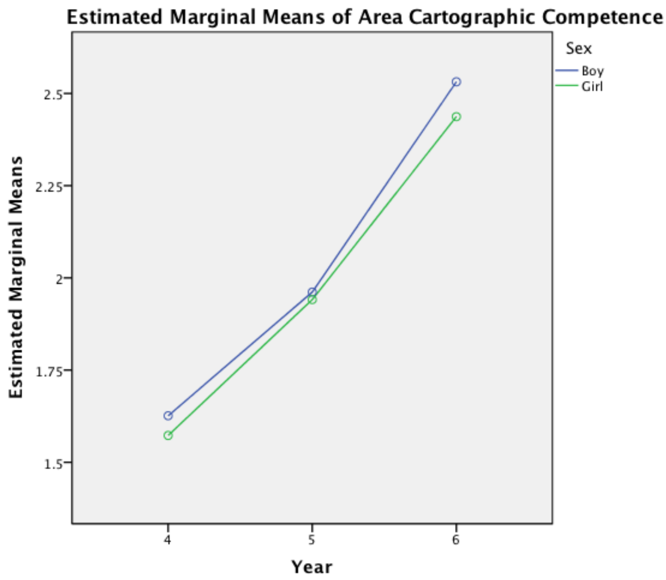


Figure 8-18: Average area map style scores by sex and school year

The graph shown above in Figure 8-18 shows the overall average area map style score for boys and girls over the three school years under consideration. The increase of average score as school year increases is, once again, apparent. The main effect for school year is highly significant $F_{(2, 253)} = 41.65, p < 0.0005$. The graph also shows separate lines for boys and girls. After examining the graph it is no surprise that there is no significant main effect of sex, $F_{(1, 253)} = 0.61, p = 0.437$, nor is there any interaction between sex and school year $F_{(1, 253)} = 0.23, p = 0.978$.

The remaining interactions, sex*school, and sex*year*school, are not significant, $F_{(1, 253)} = 0.227, p = 0.635$ and $F_{(1, 253)} = 0.909, p = 0.341$, respectively.

8.10.3 Common findings for route and area sketch maps

Table 8-3, shown below, summarises the findings for the main effects and interactions for cartographic competence ANOVAs

Table 8-3: Summary of the significant effects for the cartographic competence ANOVAs

	Route Map Score	**Area Map Score**
Sex	*Not significant*	*Not significant*
Year	**Significant**	**Significant**
School	*Not significant*	**Significant**
Sex * Year	*Not significant*	*Not significant*
Sex * School	*Not significant*	*Not significant*
Year * School	**Significant**	**Significant**
Sex * Year * School	*Not significant*	*Not significant*

The results in the section above suggest that on average, scores for the area maps are higher than scores for route sketch maps. However, the average scores for route maps and area maps are based on different sized samples: 271 children for route maps and 263 children for the area maps. The results for both types of sketch map are considered in more detail in the next section.

The average scores for the route sketch map and area map cartographic competence show very similar patterns. The most obvious finding is that there is a clear age gradient in the development of cartographic competence; there are significant differences in the proportion of children producing the more advanced plan and plan-pictorial representations as we progress through the school years.

Also interesting is the lack of a main effect for sex in both area and route sketch maps. It has been noted previously that it can be tempting to extend the results of paper and pencil tests that include small-scale abstract problems, which often find a male advantage, to predict that females will be less competent when it comes to tasks that involve large-scale spatial tasks in the real world. While the task of drawing a sketch map is at a remove from the task of wayfinding in the local environment, it does have its basis in solving spatial problems at a large-scale that involve information gathered from the real world.

8.11 Comparing area map and route map cartographic competence

The tables below (Table 8-4 and Table 8-5) compare the cartographic competence for area sketch maps and route sketch maps. The sample for the comparisons in this section only use results for children who have completed both maps (N = 262).

Table 8-4 below compares the average rating for cartographic competence, based on a score of 1–3 for each map, for both area and route maps. It can be seen that the average rating is higher for the area maps for all combinations of school year, sex and school

Table 8-4: Comparison of average ratings for area map and route map cartographic competence

	School Year	Sex		Route map	Area map
Burleigh Primary School	Year 4	Boys	Mean	1.23	1.61
			SD	*0.43*	*0.79*
		Girls	Mean	1.19	1.60
			SD	*0.40*	*0.65*
	Year 6	Boys	Mean	2.42	2.87
			SD	*0.65*	*0.34*
		Girls	Mean	2.13	2.64
			SD	*0.69*	*0.49*
Flamstead End Primary School	Year 4	Boys	Mean	1.38	1.65
			SD	*0.49*	*0.75*
		Girls	Mean	1.23	1.55
			SD	*0.43*	*0.60*
	Year 5	Boys	Mean	1.44	1.96
			SD	*0.58*	*0.87*
		Girls	Mean	1.60	1.94
			SD	*0.65*	*0.78*
	Year 6	Boys	Mean	1.94	2.19
			SD	*0.68*	*0.70*
		Girls	Mean	1.86	2.24
			SD	*0.65*	*0.54*

Table 8-5 shows a similar comparison, but in this case a comparison of the different map ratings is being made at the per child level. The table shows a comparison of the ratings given to the area map and the route maps, for children who supplied both types of map. The table shows how many children have maps that were rated at the same level, how many children had a higher rated area map, and how many children had a higher rated route map. The table shows each combination of school year, sex and school. The percentage figures in the table represent the percentage of each row that fall into each category.

Table 8-5: Comparison of average ratings for area map and route map cartographic competence

			Which map has the higher value for cartographic competence		
	School Year	Sex	Equal	Route map	Area map
Burleigh Primary School	Year 4	Boys	13 (46%)	4 (14%)	11 (39%)
		Girls	12 (48%)	2 (8%)	11 (44%)
	Year 6	Boys	13 (57%)	0 (0%)	10 (44%)
		Girls	10 (46%)	1 (5%)	11 (50%)
Flamstead End Primary School	Year 4	Boys	19 (61%)	3 (10%)	9 (29%)
		Girls	13 (59%)	1 (5%)	8 (36%)
	Year 5	Boys	9 (36%)	3 (12%)	13 (52%)
		Girls	17 (50%)	5 (14%)	12 (35%)
	Year 6	Boys	15 (48%)	5 (16%)	11 (36%)
		Girls	9 (43%)	2 (10%)	10 (48%)

The results in Table 10-5, above, show that in all cases there are more children who have a higher rated area map, than children who have a higher rated route map. The table also shows how many children received the same rating for both maps, which is what might have been expected prior to examining the data.

It is possible, that the when rating the sketch maps, the raters were just more impressed with the area maps, and so gave them higher ratings. Two more interesting explanations suggest themselves: the first that there is something about the style of recall, or the information being recalled that leads to what appear to be more advanced spatial skills being employed for the area map task; the second possibility is that there is something about the location of the schools that means that the space is intrinsically easier to represent than the space covered on the journey to school.

Taking the second possibility first, the differences between the wards for the two schools have already been discussed; Flamstead End Primary School is in a less deprived ward with lower density housing and more access to green space. It is likely that most of the children live in largely residential areas of Cheshunt, and travel into a more heterogeneous area to attend school. In this explanation, there is simply very little to differentiate the space until the child gets close to the school. Figures 8-19 and 8-20 below show residential areas of Cheshunt, it can be seen that there is little that stands out that could act as a distinctive landmark in either picture.

Figure 8-19: Example of a residential area in Cheshunt

Figure 8-20: Example of another residential area in Cheshunt

If the lack of distinctive buildings, and other objects, in the environment is part of the explanation, then it might be expected that the effect would be more pronounced for the children at Burleigh Primary, which is closer to the shops, restaurants and other distinctive landmark possibilities that are found in the centre of Cheshunt, especially near the Fountain Roundabout, also known as the Old Pond. Figure 8-21 below shows some of the bright signage that make the shops, cafes and other buildings in the area into distinctive, possibly more memorable, units.

Figure 8-21: Some of the bright and distinctive shops and cafes on the approach to the fountain roundabout

The effect, area maps being more highly rated than route maps, is more pronounced for children are Burleigh Primary, but the differences, while systematic, are not large. It is possible, then, that the increased heterogeneity of the local environment around the school plays a part in the explanation.

Returning to the first possibility suggested, that there may be something about the area mapping task that brings out a more advanced spatial representation. It could be argued that as the area map deals with landmark recall and landmark placements, it is a very different style of recall from the route map, which actually requires the children to recall both routes and landmarks. If we return to the suggestion that cognitive mapping skill can be graded according to a progression from landmark, through route to map-like knowledge, then it could be argued that asking children to supply a representation of a route is a more complex task, relying on a higher grade of mapping ability, than asking for the positions of landmarks. So it might be argued that children’s performance appeared higher for the easier, in terms of the cognitive spatial skills involved, task.

As has already been noted, children included landmark information with their routes, in some cases children produced quite “fat” routes, including a lot of off route information. Also, in many cases the area map sketches include a linking network. The difference in complexity of the task may have some influence, but it is clear that both tasks included elements of the other.

8.12 Time spent in walk and car travel

The time spent in different travel modes was taken from the CATS (Children, Activity and Travel Survey) diary. At the two Cheshunt schools the diary was only given to children who volunteered for the CATS activity monitoring study, so detailed diary data are not available for all the children who completed the sketch mapping tasks. The travel durations were calculated as the difference between the time that a child left one location and arrived at the next location, the "I left at" and "I got there at" fields in the diary (see Figure 4-10 and Appendix 2). Table 8-6 below shows the numbers of children with area sketch maps and detailed travel and activity data.

Table 8-6: Number of children included who have CATS diaries and area sketch map results

	Year 4	Year 5	Year 6	All Years
Boys	22	26	14	62
Girls	28	36	20	84
Both Sexes	50	62	34	146

The total duration of different travel modes was calculated for days during the week and days at the weekend, information about travel mode comes from the "I travelled by" field in the CATS diary (see Figure 4-10 and Appendix 2). Table 10-7 below shows the average time in minutes that the children spent in each of the different modes, the results are broken down by school year and sex, and standard deviations for the mean figures are also included.

Table 8-7: Average duration (minutes) of the children's travel by different modes, taken from the CATS diary

			Car	Walk	Bicycle	Bus	Train	Other
Year 4	Boys	Mean	155.9	59.8	0.0	0.0	0.0	0.0
		S.D.	*118.7*	*90.6*	*0.0*	*0.0*	*0.0*	*0.2*
	Girls	Mean	153.8	35.5	0.2	6.7	0.0	0.0
		S.D.	*141.2*	*46.1*	*0.9*	*34.9*	*0.0*	*0.0*
Year 5	Boys	Mean	157.9	65.1	8.5	0.0	0.0	0.0
		S.D.	*137.0*	*94.1*	*26.4*	*0.0*	*0.0*	*0.0*
	Girls	Mean	169.2	42.1	4.3	0.0	0.0	1.2
		S.D.	*87.4*	*49.2*	*15.5*	0.0	*0.0*	*5.4*
Year 6	Boys	Mean	139.2	22.3	5.1	0.0	0.0	0.0
		S.D.	*81.6*	*23.9*	*14.3*	*0.0*	*0.0*	*0.0*
	Girls	Mean	113.6	50.4	2.7	2.3	2.3	0.8
		S.D.	*77.7*	*50.1*	*7.5*	*16.6*	*10.*	*5.5*
Total	Boys	Mean	152.4	52.3	4.5	0.0	0.0	0.0
		S.D.	*118.1*	*82.4*	*18.1*	*0.0*	*0.0*	*0.1*
	Girls	Mean	146.0	42.9	2.5	2.8	0.8	0.7
		S.D.	*106.5*	*48.8*	*10.4*	*21.7*	*5.9*	*4.6*

It can be seen from Table 8-7 that, in comparison with the average amount of time spent in the dominant modes of walk and car, time spent in other modes is very small. In fact the contribution of other modes is even smaller than indicated above, as the category "Other" in Table 8-7 includes entries in the children's diaries where the child had recorded a mixture of car and walk in a single journey, and had decided, in a diary feedback session, that neither could be described as a main mode of travel. The "Other" category is quite diverse, as it also includes other active modes, for instance skateboard, and other passive modes, including travel by London Underground.

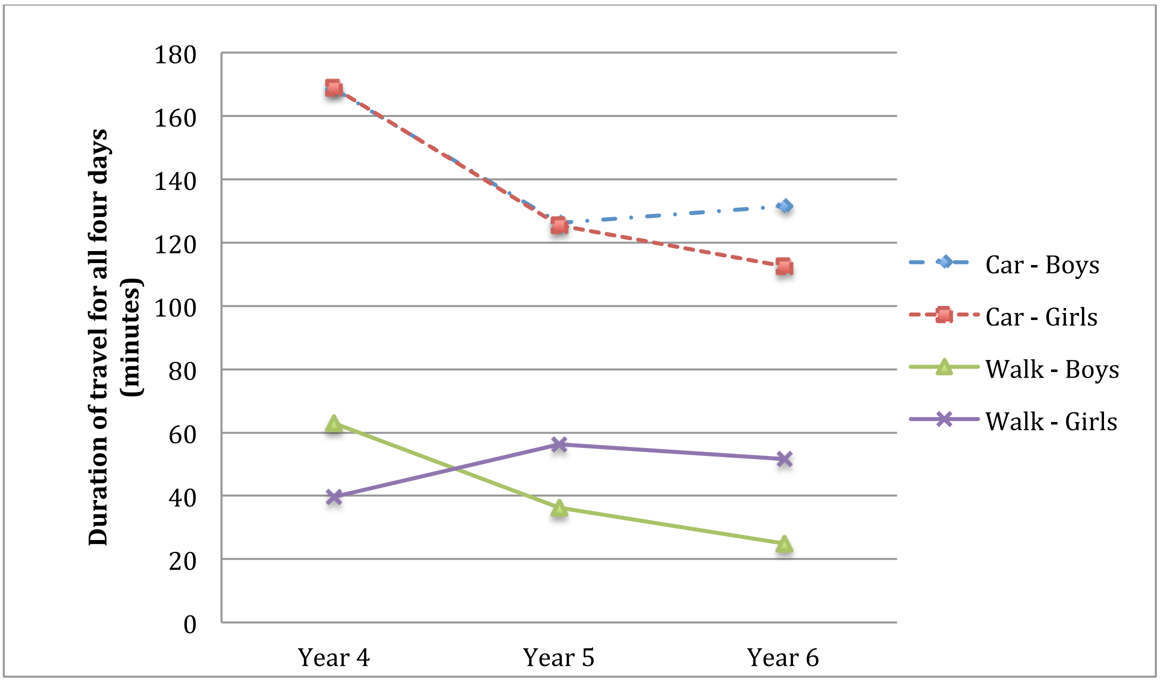


Figure 8-22: Walk and car durations for boys and girls over three school years

Figure 8-22 above shows how the duration of car and walk travel changes over the three school years. Durations are shown in minutes, with separate lines for boys and girls. There is a significant fall in the duration of car use between Year 4 and Year 6.

A 2 way, sex * school year, ANOVA shows the fall in the duration of car use is significant $F_{(2, 129)} = 3.6$, $p = 0.031$. There is no significant main effect from the sex of the child, and no significant interaction between sex and school year.

Analysing the duration of walking journeys in the same way reveals that there are no significant main effects for, and no interaction between, the factors for sex and school year.

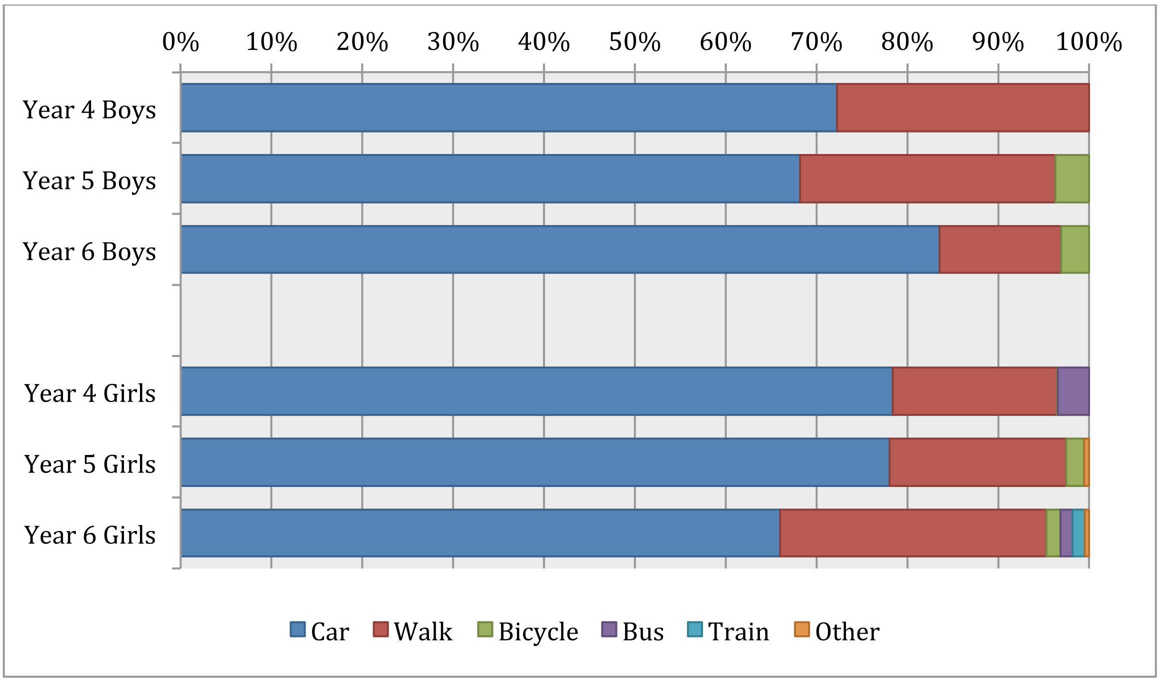


Figure 8-23: Percentage of time spent in travel by different modes by sex and school year

The relative contribution made by each mode to the children's overall time spent travelling is shown above in Figure 8-23. Because walking and car journeys make up by far the largest proportion of the journeys made by the children in the sample these are the modes that will be compared in the subsequent analysis.

It is interesting to note that while car use for girls seems to fall as age (school year) increases, for boys there is an increase between Year 4 and Year 6 (albeit with a slight fall in Year 5).

8.13 Defining a simple measure of mode choice

As walk and car are the two main types of travel mode used in the sample, the children will be given an overall mode based on whether they spend more time walking than using the car. If the total duration of walking is greater than the total duration recorded for car use, then the child is assigned to the walk group, otherwise they are assigned to the car group. Cases where car duration and walk duration are equal would be assigned to the car group. Table 8-8 shows the number of children in each group.

Table 8-8: Number of children assigned to the walk and car groups, according to whether the overall duration of walking is greater than the overall duration of car use

	Boys		Girls		Both sexes	
	Walk	Car	Walk	Car	Walk	Car
Year 4	20	32	22	16	42	48
Year 5	23	25	22	31	45	56
Year 6	27	24	22	15	49	39
All years	70	81	66	62	136	143

The groups created in this way are relatively well balanced, the graphs in Figure 10-19, shown below, show the percentage of children who fall into each group for each sex, school year combination.

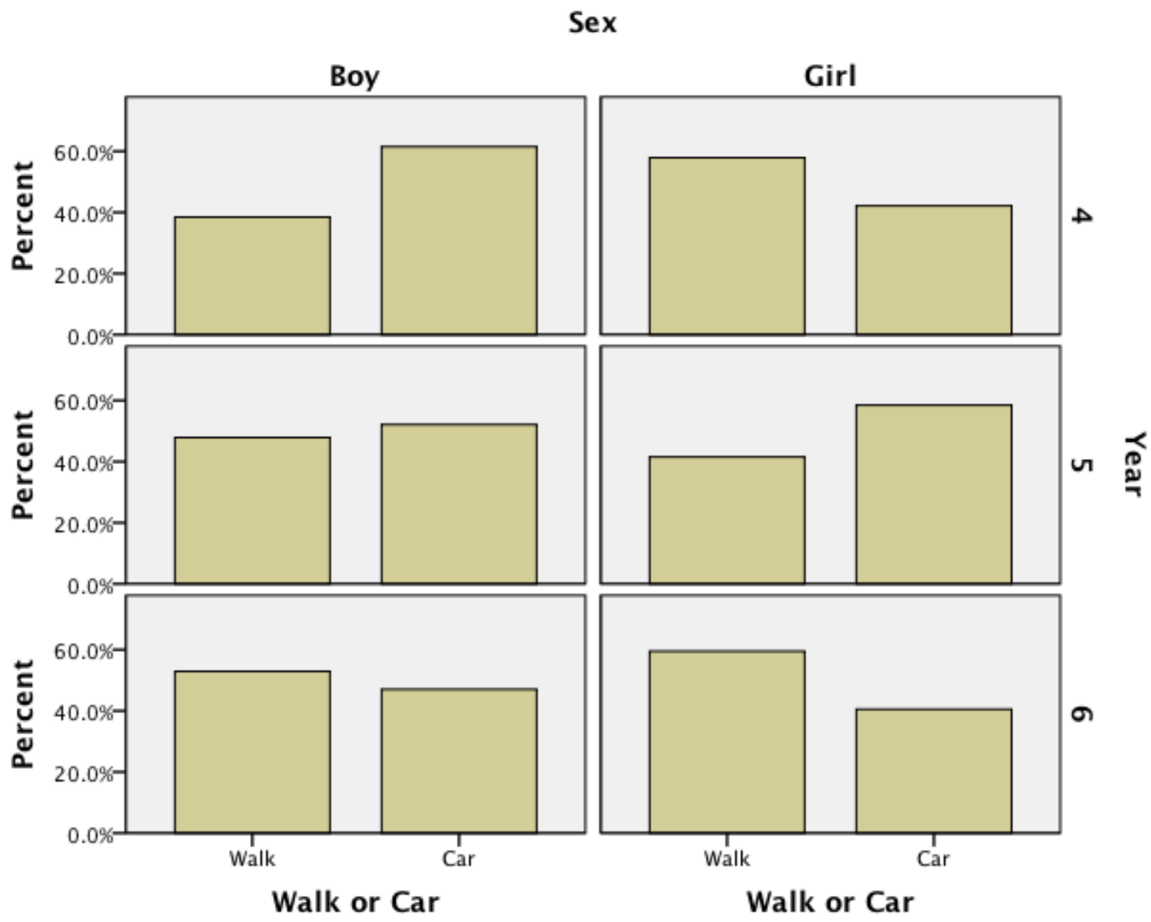


Figure 8-24: Graphs showing the percentage of children assigned to the car or walk group according to whether the overall duration of walking is greater than the overall duration of car use

The following sections will compare cartographic competence between walk and car groups.

8.14 Comparing travel mode and cartographic competence

The graphs in Figures 8-25 and 8-26, shown below, gives a simple graph showing the proportion of each cartographic competence divided between the car group and the walk group. The first graph shows the results for route map cartographic competence, the second shows the results for area map cartographic competence.

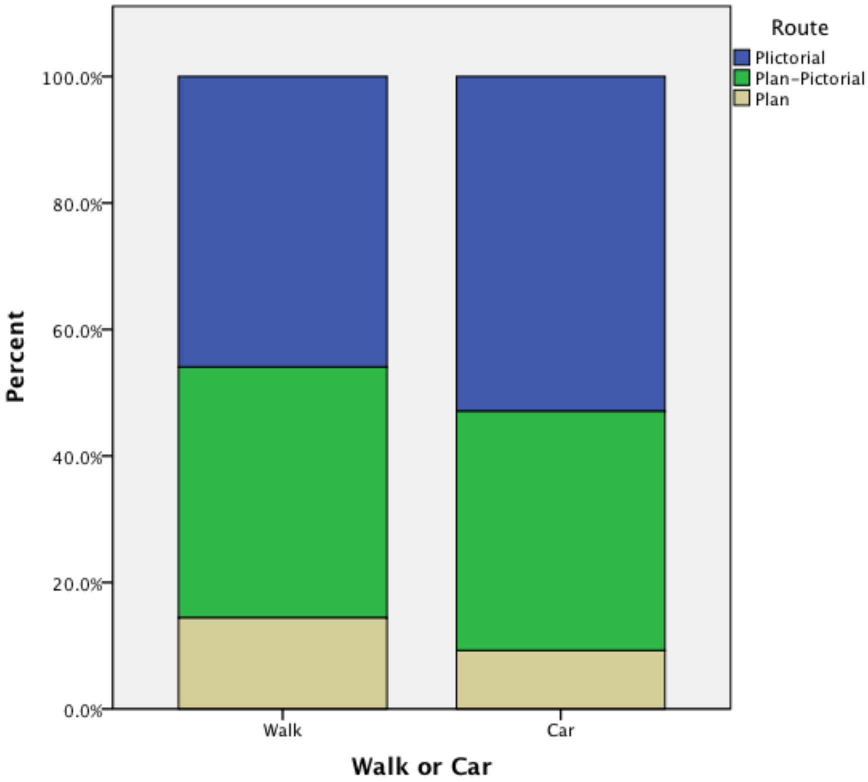


Figure 8-25: Differences in cartographic competence for route sketch maps between the two travel mode groups

There is a slight increase in the proportion of plan-pictorial style maps in the car group, and a slight decrease in the proportion of plan maps. This suggests that the maps produced in the walk group are more likely to be more sophisticated. There is no significant difference, however, χ^2 (2, N = 230) = 1.92, p = 0.38.

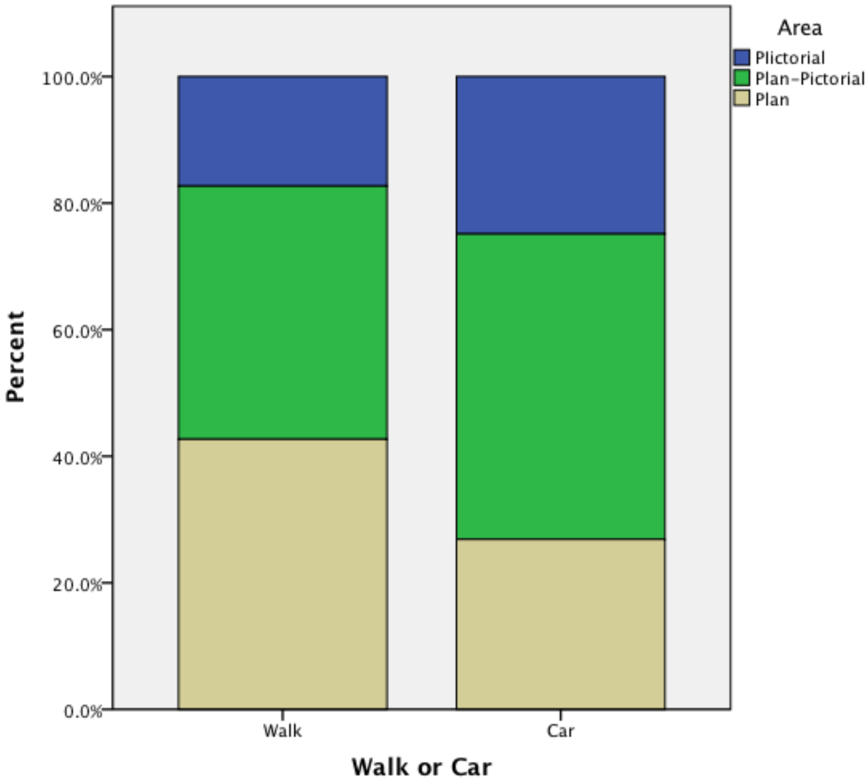


Figure 8-26: Differences in cartographic competence for area sketch maps between the two travel mode groups

Once again there is an increase in the proportion of plan-pictorial style maps in the car group, and a decrease in the proportion of plan maps. The differences are more marked for the area sketch maps. The differences suggest that the maps produced in the walk group are more likely to be more sophisticated. In this case there are significant differences in the proportions of maps assigned to each category, χ^2 (2, N = 223) = 7.08, p = 0.029.

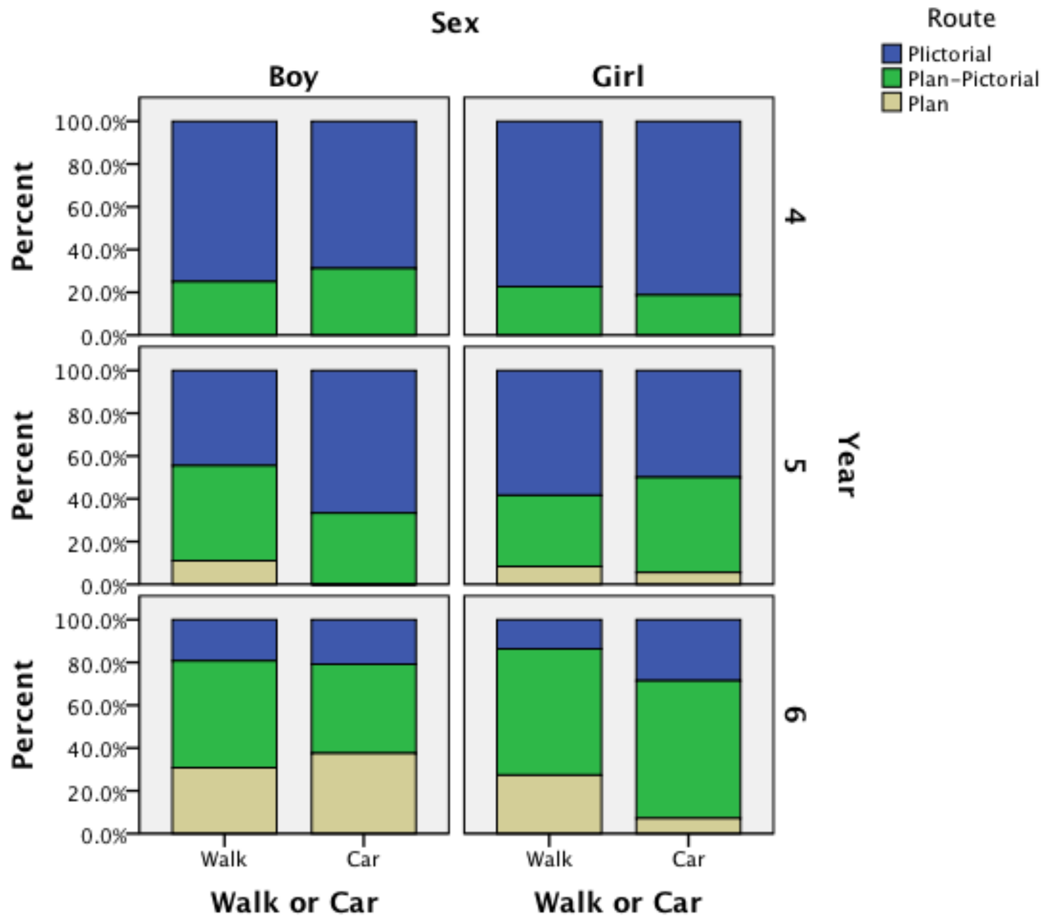


Figure 8-27: Percentage of route maps that are categorised in each style for each sex and school year combination

Figure 8-27, above shows the percentage of route maps that are categorised in each style for each sex and school year combination, there seems to be no clear pattern based on the mode use groups. A similar series of charts are shown below, in Figure 8-28, in these charts, it is the categorisation of the route sketch maps that is under consideration. The graphs seem to show a fairly consistent advantage of the walk group when it comes to producing area maps that can be classified as plan maps, except in the case of girls in Year 4.

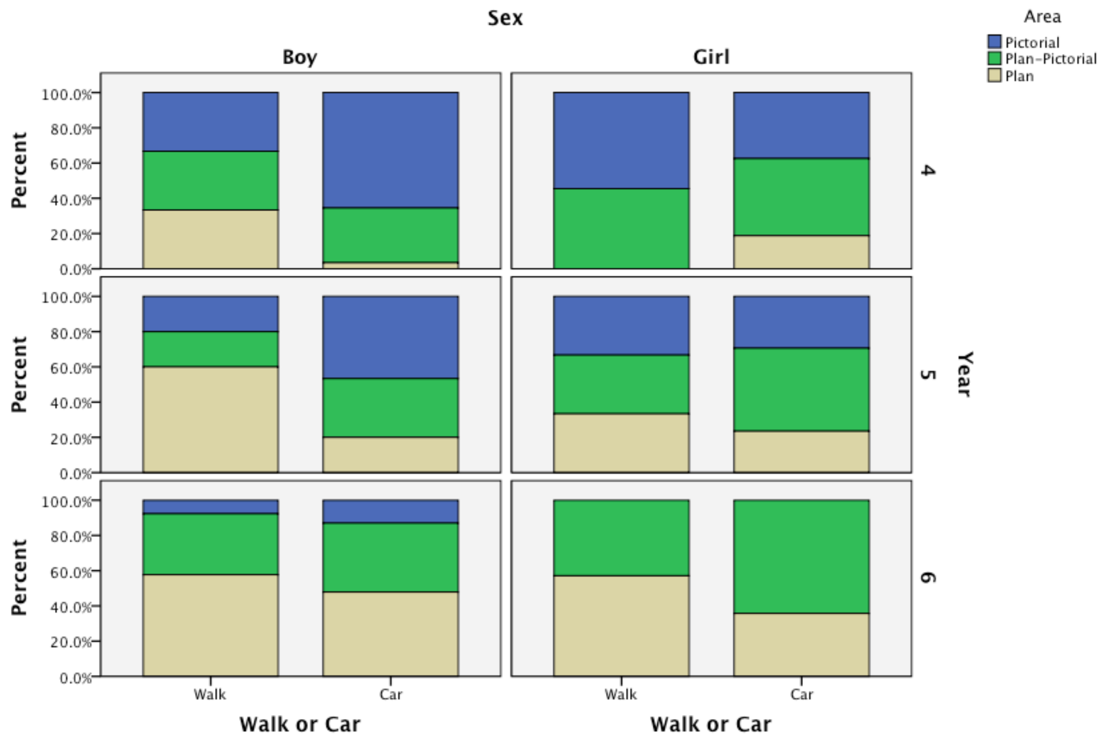


Figure 8-28: Percentage of area maps that are categorised in each style for each sex and school year combination

8.15 Cartographic competence and main mode: interactions

Once again an ANOVA model will be employed to study the contributions of different factors thought to influence the level of cartographic competence. The factors considered in this section are all between subjects factors: a 2 level factor representing the sex of the child, a 2 level factor for the main mode measure and a 3 level factor the child's school year. Two 2*2*3 ANOVA models will be considered, the first will use the assessment of the route sketch mapping task as the dependent variable, the second will take the assessments of the route sketch mapping task as the dependent variable. As in the previous ANOVA comparisons, the children's results will be treated as if they are scores between 1 and 3, where 1 represents a pictorial map, 2 a plan-pictorial map and 3 represents a plan style map.

Again we should note that the results should be treated with some caution as the dependent variable is at the ordinal rather than the scale level, so the data does not meet the strict criteria for the use of the ANOVA test.

8.15.1 Route map cartographic style ANOVA, considering main mode

The graph in Figure 8-29 shows the overall average route map style score for children in both mode groups (assigned by whether car or walk is the most used mode) against the child's school year. The blue points in Figure 8-29 show the average ratings for children in the walk group, and the green points show the average ratings for the children in the car group.

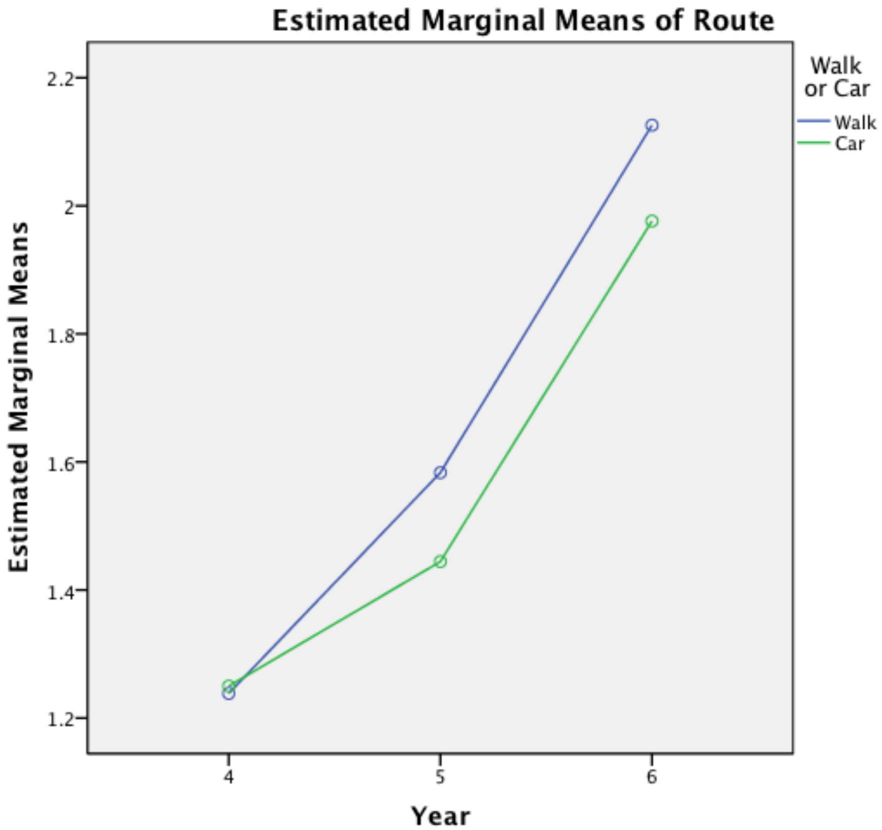


Figure 8-29: Mean route map score by mode and school year

The ANOVA described above only reveals a significant main effect for school year, the child's sex and mode group do not have significant main effects. There are no significant interactions. Details of F ratios, degrees of freedom and p values are shown below in Table 8-9.

Table 8-9: Summary of ANOVA results for route map style classification, considering the contribution of school year, child's sex and main mode

Factor	***df***	**F**	***p***
Year	2, 218	40.27	< 0.0005
Sex	1, 218	0.85	0.358
WalkvCar	1, 218	1.28	0.260
Year * Sex	2, 218	0.50	0.605
Year * WalkvCar	2, 218	0.46	0.629
Sex * WalkvCar	1, 218	0.06	0.814
Year * Sex * WalkvCar	2, 218	1.78	0.171

8.15.2 Area map cartographic style ANOVA, considering main mode

The graph in Figure 8-30 shows the overall average area map style score for children in both mode groups (assigned by whether car or walk is the most used mode) against the child's school year. The blue points in Figure 8-30 show the average ratings for children in the walk group, and the green points show the average ratings for the children in the car group.

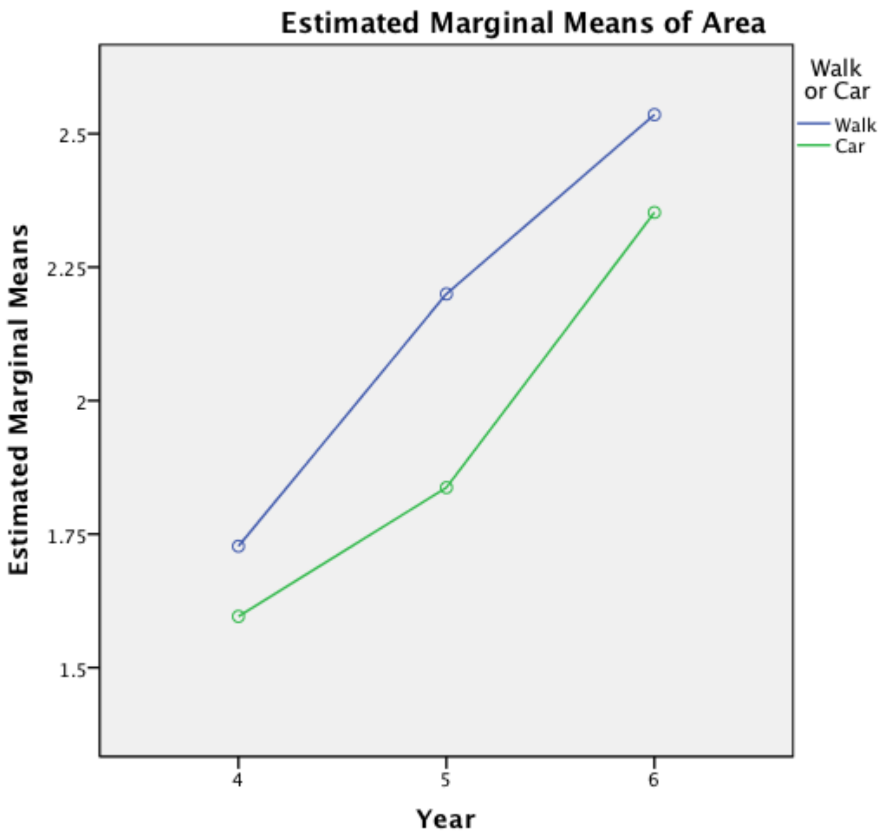


Figure 8-30: Mean area map score by mode and school year

The ANOVA described above reveals a significant main effect for the main mode of the child, $F_{(1, 253)} = 5.64$, $p = 0.018$. There is also a main effect for school, and a significant interaction between sex and main mode. There are no other significant main effects or interactions. Details for all F ratios, degrees of freedom and p values are shown below in Table 8-10.

Table 8-10: Summary of ANOVA results for area map style classification, considering the contribution of school year, child's sex and main mode

Factor	***df***	**F**	***p***
Year	2, 211	26.73	< 0.0005
Sex	1, 211	0.15	0.695
WalkvCar	1, 211	5.64	0.018
Year * Sex	2, 211	0.18	0.832
Year * WalkvCar	2, 211	0.48	0.620
Sex * WalkvCar	1, 211	7.14	0.008
Year * Sex * WalkvCar	2, 211	3.01	0.052

A marginal means plot, shown in Figure 8-31, can be made to show the interaction between child's sex and the main mode; this plot shows that the interaction is really quite dramatic. The graph below seems to suggest that it is the boys who are being impacted by any differences that exist between walking and car use. Main mode seems to make very little difference to the average rating of the girl's area sketch maps.

If we exclude all the girls and only consider the boys in the sample, the relationship between main mode and cartographic competence rating is even stronger $F_{(1, 253)} = 12.16$, $p = 0.001$.

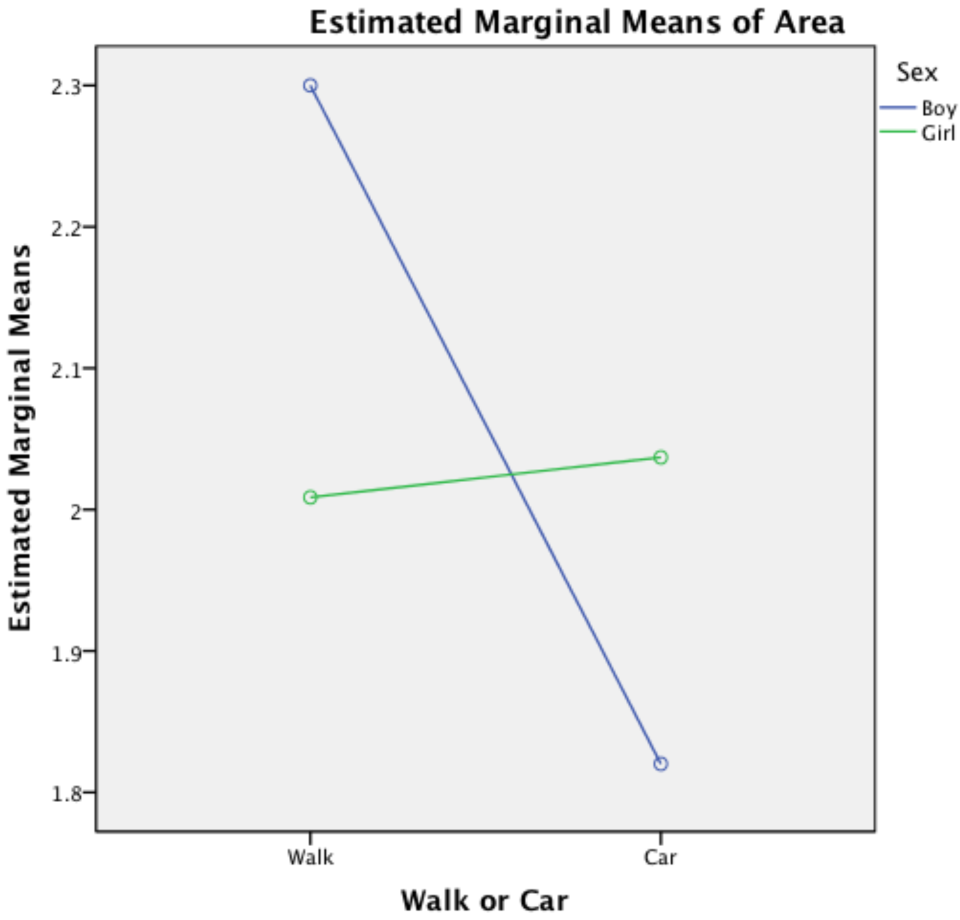


Figure 8-31: Graph illustrating the interaction between main mode and child's sex

8.16 Chapter summary

This chapter began with a comparison of real world and represented distance, it is possible to show that the distances in the sketch maps are shown in a non-linear fashion. The distances are generally categorically correct, they occur in the right distance sequence, but large distances are shrunk in relation to closer distances.

It is unclear if this finding reflects children employing a logarithmic scaling factor as they recall data, or if it shows that they needed a larger sheet of paper.

The chapter goes on to show how the data from the children's sketch maps can be analysed in a global fashion. The style of representation is classified as one of three grades, which is interpreted as an indicator of the child's level of development. School year and the school the child attends emerge as important factors in determining the child's cartographic competence. The sex of the child does not have a significant influence.

The analysis also considers how children's travel mode might affect children's representations. Data about the duration of children's travel was used to divide the children into two groups, based on whether they spend longer walking than using the car during the diary study. Subsequent analysis reveals that there are significant advantages, in terms of cartographic competence, for children who walk more than they use the car. Studying the interactions shows that the difference between walkers and car users is only present in the boys; girls' scores are roughly equivalent between the two groups.

9 Area sketch map landmarks

9.1 Area maps included in the study

232 (83%) of the children returned area sketch maps that could be analysed for accuracy. To be included in the analysis the maps needed to include at least two elements: one unambiguously identifiable element added by the child, in addition to the school. Without at least two elements the map could not be analysed using bidimensional regression.

Table 9-1 shows the children included in the analysis of area sketch map accuracy by sex and school year. Table 9-1 shows the children both as a count and as a percentage of the children who took part in the exercise.

Table 9-1: Children included in the analysis of area sketch map accuracy, shown as a count and a percentage of the children who took part in the exercise

	Year 4	Year 5	Year 6	All Years
Boys N *(%)*	48 (75%)	26 (100%)	45 (78%)	119 (80%)
Girls N *(%)*	40 (83%)	33 (94%)	40 (85%)	113 (87%)
Both Sexes	88 (79%)	59 (97%)	85 (81%)	232 (83%)

There does not appear to be a clear pattern in the school year and sex for those who do or do not return a sketch map that could be analysed for accuracy.

9.2 Landmarks included in the area sketch maps

9.2.1 Number of elements included in the area sketch maps

Table 9-2 shows the number of unique elements included in the children’s sketch maps.

Table 9-2: Number of elements included in the children’s sketch maps

	Burleigh Primary	Flamstead End	Both schools
Unique elements	84	187	271
Elements included in all maps	400	1091	1491

The map of Cheshunt, shown below in figure 9-1, shows the real world positions of all the elements added by the children in the study.

9.2.2 Spatial distribution of the elements included in the area sketch map

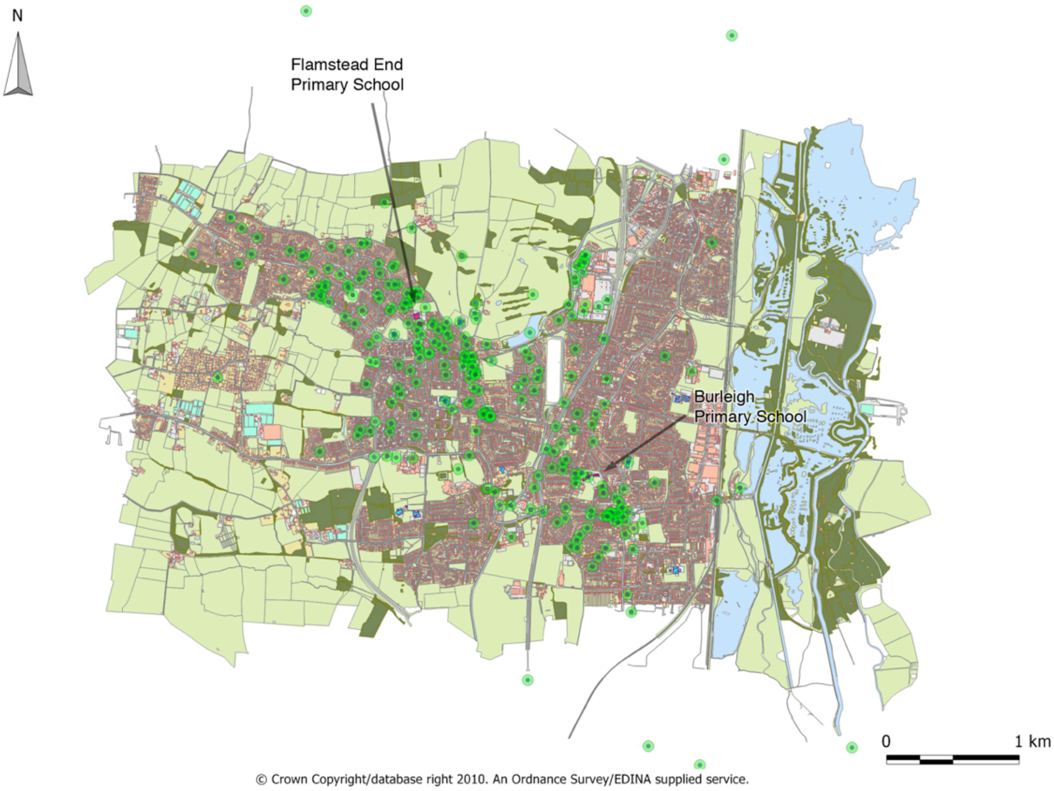


Figure 9-1: Map showing the position of the sketch map elements included by the children in Area Sketch Mapping exercise

In Figure 9-2, below, the locations of the sketch map elements have different markers depending on the school that the children attend, and the number of maps that include that element. The size of the element is proportional to the number of maps that include the element. The colour and style of the marker indicates whether the element was included exclusively by Flamstead End children, exclusively by Burleigh Primary children, or included by children at both schools. Yellow markers with a diagonal cross indicate elements that were only included in maps by children from Flamstead End Primary School, elements that were only included by children at Burleigh Primary School are indicated by blue markers with a upright cross, and green markers with a dot in the centre are used to indicate elements that were included in maps by children form both schools. The size of the points is proportional to the number of children who included a particular element.

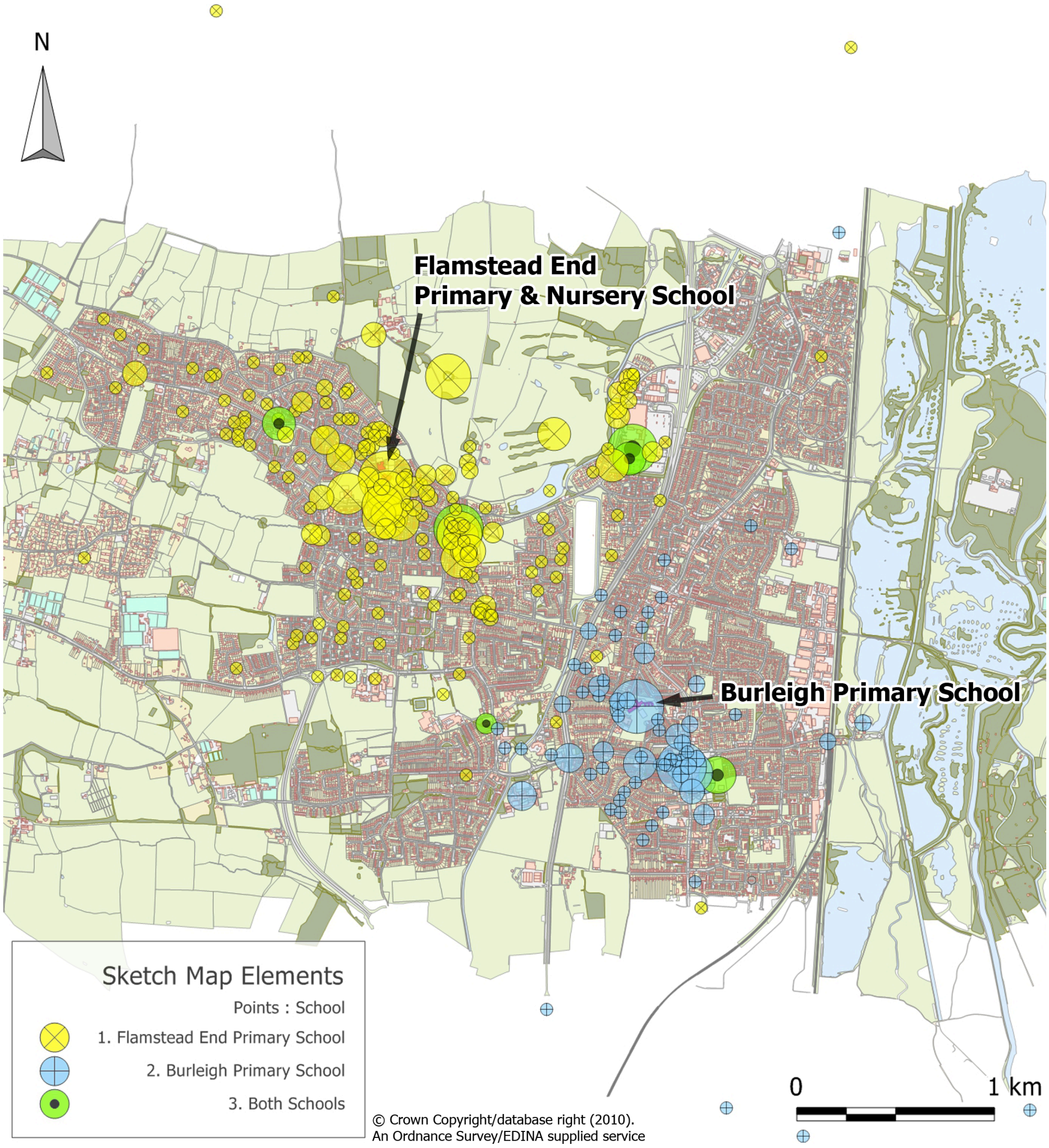


Figure 9-2: Map showing the position of sketch map elements recorded by the children in the Area Sketch Mapping exercise by school

9.2.3 Elements that were included by children at both schools

There are only six elements (from a total of 263 unique elements), see table 9-3 below, that were used by children at both schools. In most of the cases where an element was included by children at both schools, it is children from one of the schools who make the majority of mentions. For instance, "The Box", a purple hairdressers near to Flamstead End Primary School (see Figure 9-3), is almost exclusively mentioned by children at Flamstead End. It is obviously distinctive enough to have been picked up by a child from Burleigh Primary as well. Only St Mary's Church, an element that is not frequently mentioned, is included a similar amount of times by children from both schools

Table 9-3: Sketch map elements that are included by children at both schools

	Burleigh Primary School	Flamstead End Primary School	Both Schools
Grundy Park	37	1	38
Marks & Spencer (large shopping centre)	3	24	27
St Mary's church	2	4	6
Street: Dig Dag Hill	1	20	21
Tesco (Brookfield Centre near M&S)	2	71	73
The Box	1	101	102

9.3 Prominent landmarks from the children's maps

The following section considers some of the prominent landmarks that were recorded by children in the study. Figure 9-3, below, shows The Box, one of the shared landmarks. It is also the most popular landmark when considering all the maps in the study.

Figure 9-3: The Box hairdressers, a very popular landmark with the children at Flamstead End Primary School

Table 9-4 below shows the top ten most included points in the all the children's maps. The schools themselves would have been the most popular elements across all of the maps, but since they were not added by the children, they have not been included below.

Table 9-4:The ten most included elements in the children's area sketch maps

Name	N	School
The Box	102	3. Both Schools
Tesco (Brookfield Centre near M&S)	73	3. Both Schools
Old Pond/Fountain (Roundabout: Turners Hill and College Road)	70	2. Burleigh Primary School
Roundabout South of FE school (Longfield Lane)	67	1. Flamstead End Primary School
Stockwell Lodge Medical Village (Dentist/Optician/Pharmacy)	62	1. Flamstead End Primary School
Cheshunt Park	45	1. Flamstead End Primary School
Roundabout near The Box	45	1. Flamstead End Primary School
Fairfields Primary School	43	1. Flamstead End Primary School
Roundabout on Rosedale Way (near Stockwell Lodge)	42	1. Flamstead End Primary School
Tesco Metro (Tesco near fountain)	41	2. Burleigh Primary School

It can be assumed that there is some feature of the elements that are most often included in the maps that make them salient, and memorable, for the children. For elements like "The Box" it is probably a combination of the unique colour scheme and proximity to the school. The appearance of the Stockwell Lodge Medical Village in the list probably has more to do with it being a destination learnt from appointments with the dentist and from picking up prescriptions.

In the case of most of the roundabouts, however, it probably has more to do with their proximity to other prominent landmarks, rather than anything captivating about the roundabout itself. The roundabout near the school is probably included due only to its proximity to the school. Children at Flamstead End Primary School also included the roundabout near The Box a great number of times, again this is probably recalled because of its location near a prominent landmark.

There is one roundabout in Cheshunt that is a landmark in itself. Figure 9-4, below, shows The Fountain Roundabout. The roundabout itself is very large, decorated with flowerbeds and topped with a fountain. It can be seen that on its own it would represent a very striking feature, worthy of encoding in and recall from anyone's cognitive map of the local area.

Figure 9-4: The Fountain Roundabout, also known as The Old Pond, is a prominent landmark for Burleigh Primary School children

The next image, Figure 9-5, shows one of the most appealing sketch maps. It is firmly pictorial in style and the child has made little or no attempt at matching the real world spatial organisation. It does, however, feature a very recognisable representation of the roundabout shown above, complete with flowerbed and fountain. The map is also notable for including not only the car in the sketch map, but also the contents of the boot, this shows an incredible range of scales in one representation.

The map is included here to show the different ways in which elements in the real world can be represented. The sketch map in Figure 9-5 can be contrasted with the sketch map in Figure 9-6, where the same roundabout is represented in a plan style.

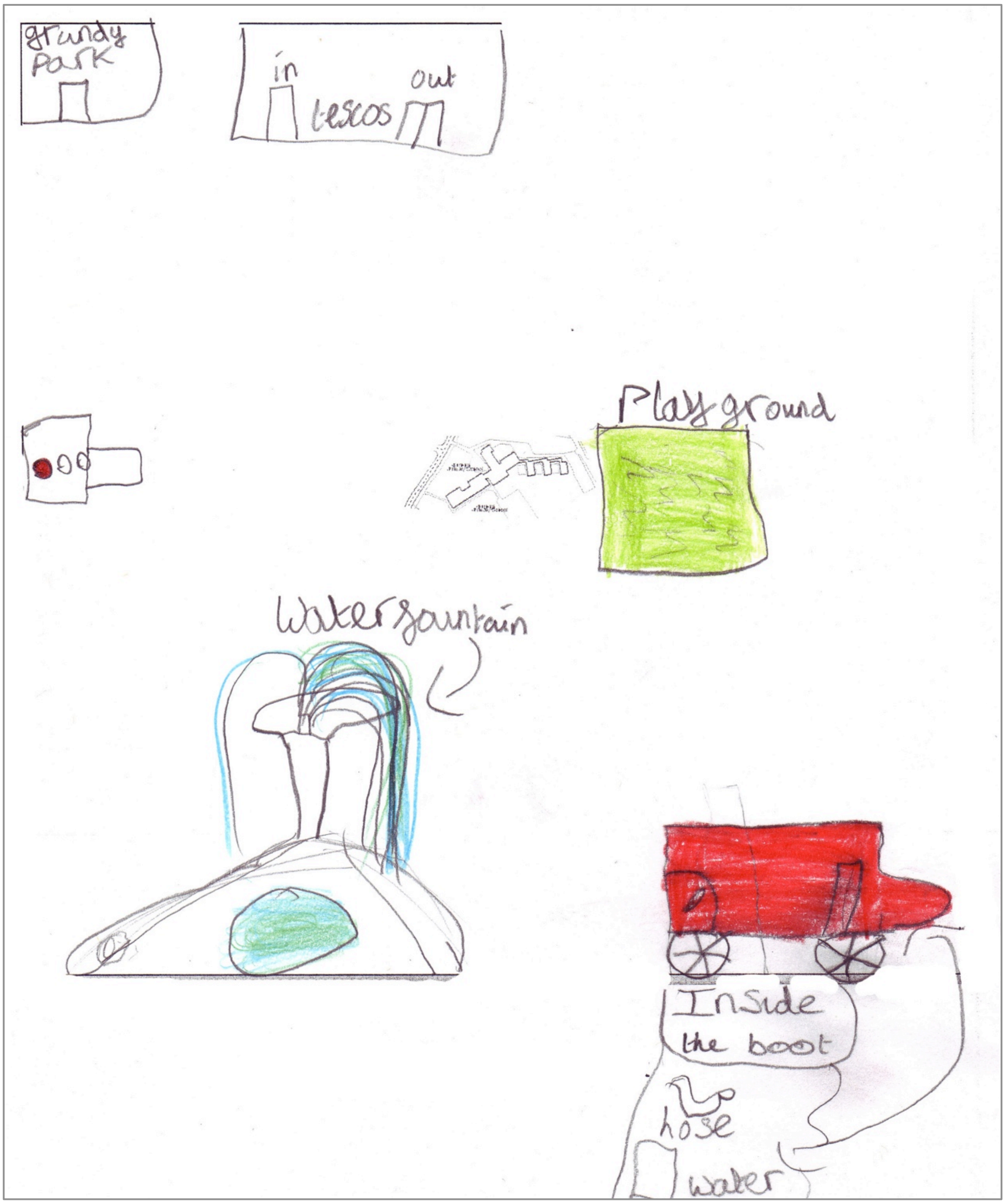


Figure 9-5: Highly pictorial representation of the local environment featuring the Fountain Roundabout

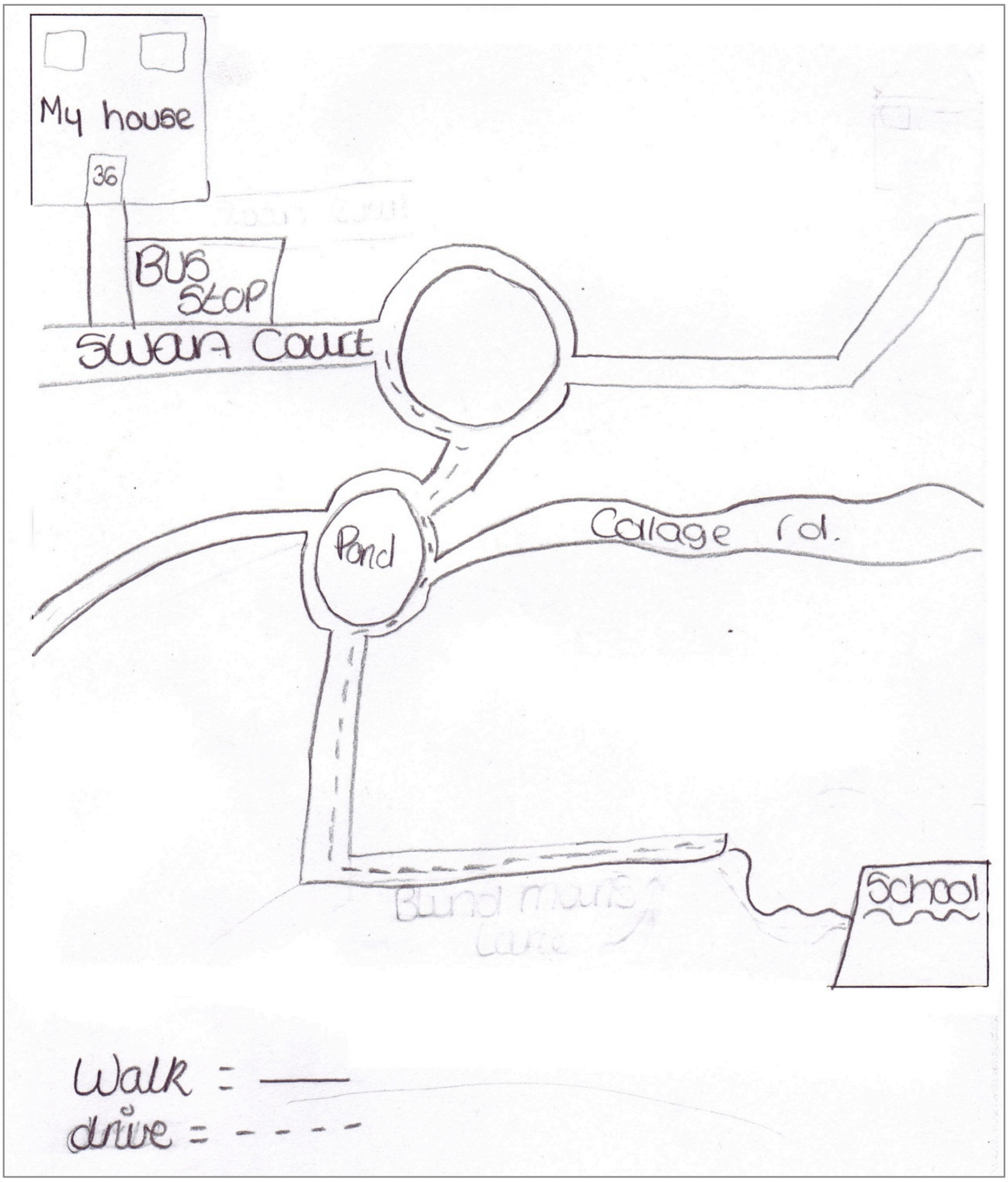


Figure 9-6: Plan style representation of the Fountain Roundabout

The Fountain roundabout is interesting not just for itself, but for the fact that it sits in the centre of a large number of buildings that were recorded as landmarks in the children's maps. Figure 9-7 below, shows a panoramic view of the roundabout, which includes a lot of the elements that children have included as elements in their sketch maps.

Figure 9-7: Panoramic view of The Fountain, also known as The Old Pond, a popular landmark for the children at Burleigh Primary School

Figure 9-8, below, shows that a large number of children (70 out of 104) from Burleigh Primary included the "Old Pond" in their area sketch maps.

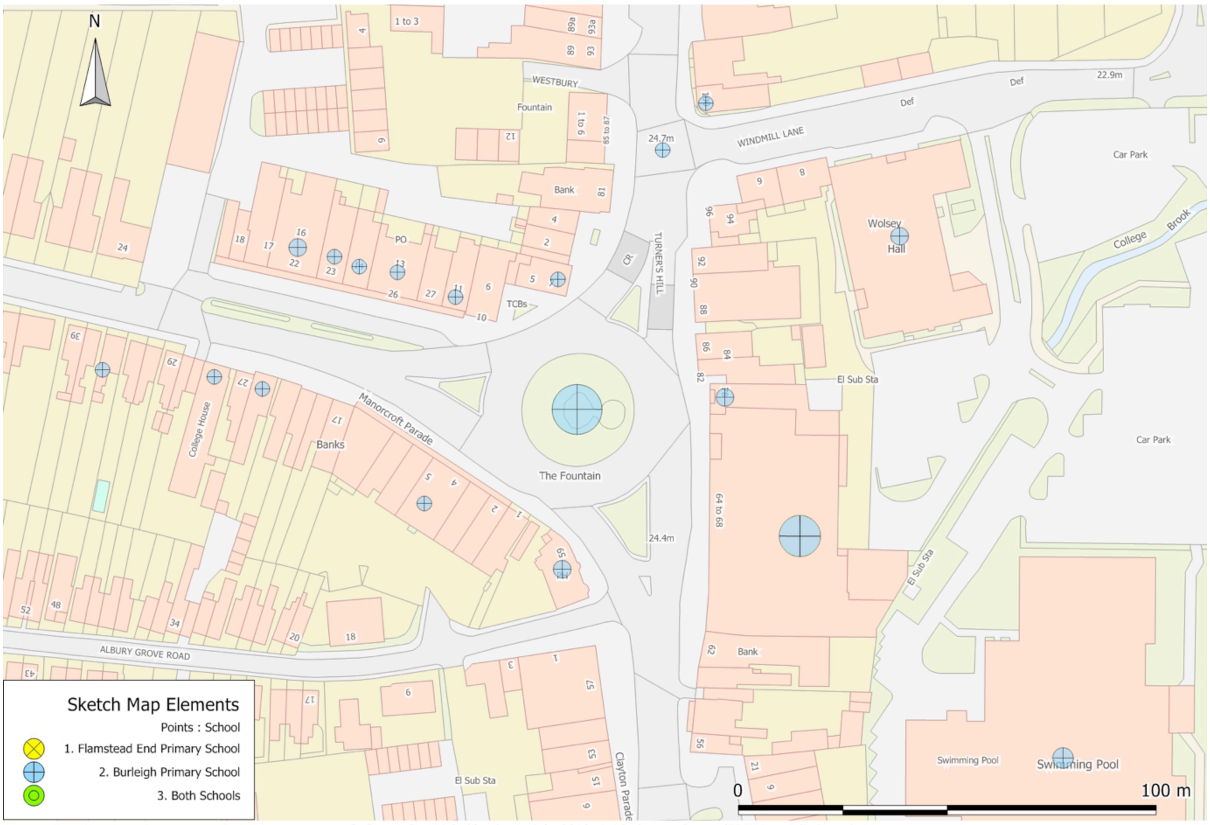


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Figure 9-8: Close up of the area around The Fountain, the area known as The Old Pond

It can also be seen from the map above that the buildings around the roundabout also act as landmarks for the children's maps. This could be an example of the opposite phenomena to that described above, in this case shops and cafes are being recalled because of their location to the roundabout, rather than vice-versa

9.4 Distribution of included elements at both schools

This section compares the areas that have been covered by the sketch map elements recorded by the children at the two primary schools. The shaded areas in Figures 9-9 (red shade with blue boundary) and 9-10 (yellow shade with red boundary), are freehand selections, and are intended to illustrative, indicating an area, judged by eye, that includes a majority of points for each school.

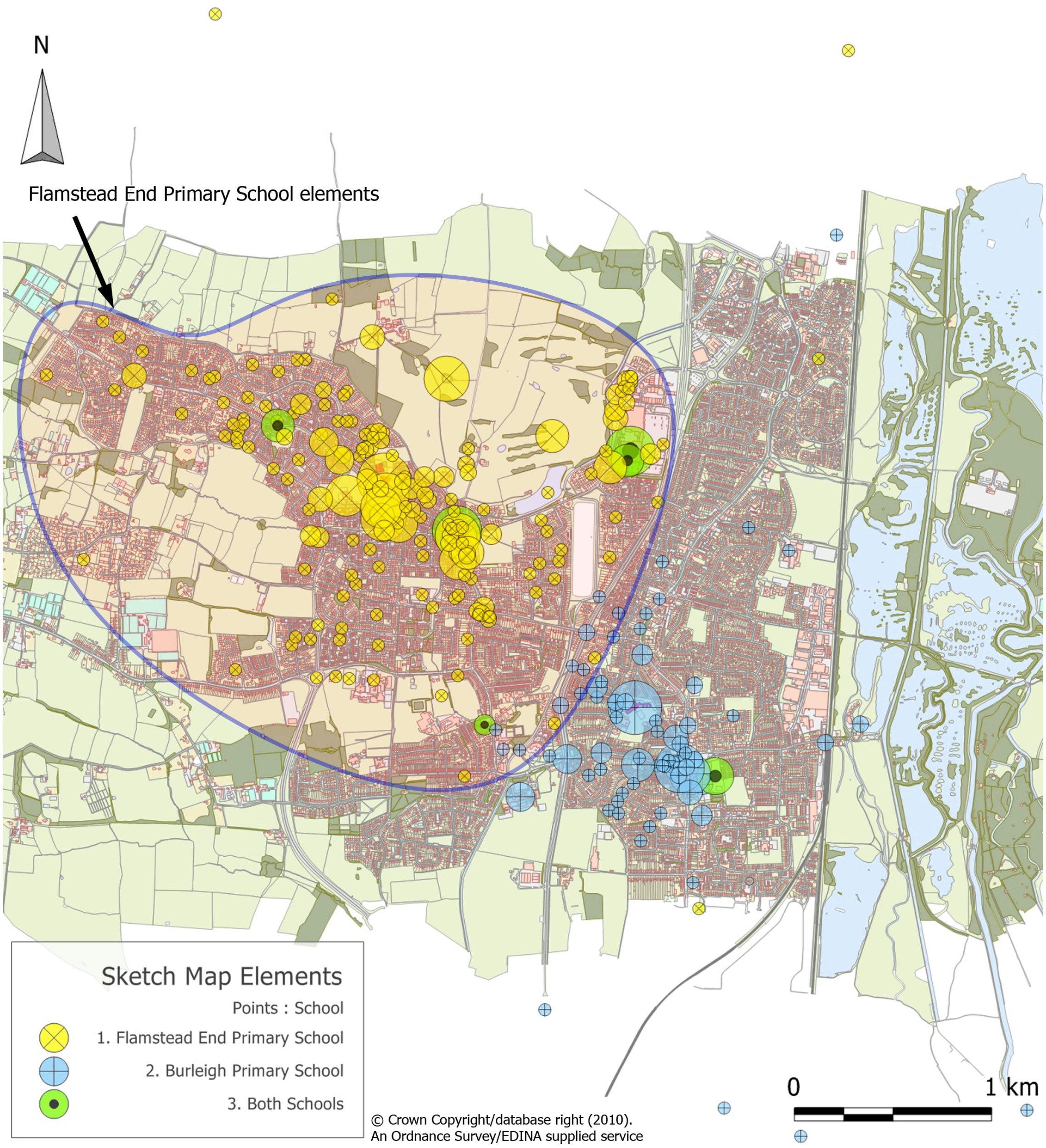


Figure 9-9: Map showing the area covered by the vast majority of points added by children at Flamstead End Primary School

The area indicated on the map above (Figure 9-9) covers the vast majority of the points that were included by the children attending Flamstead End Primary School: 97.3% of unique elements, or 99.5% of the elements included on the children's maps.

The majority of the points that were included in maps drawn by the children at Burleigh Primary school are included in the area shown in the map below (Figures 9-10): 94% of unique features, or 98.8% of included features. Figure 9-11 removes the base map to make the points more obvious.

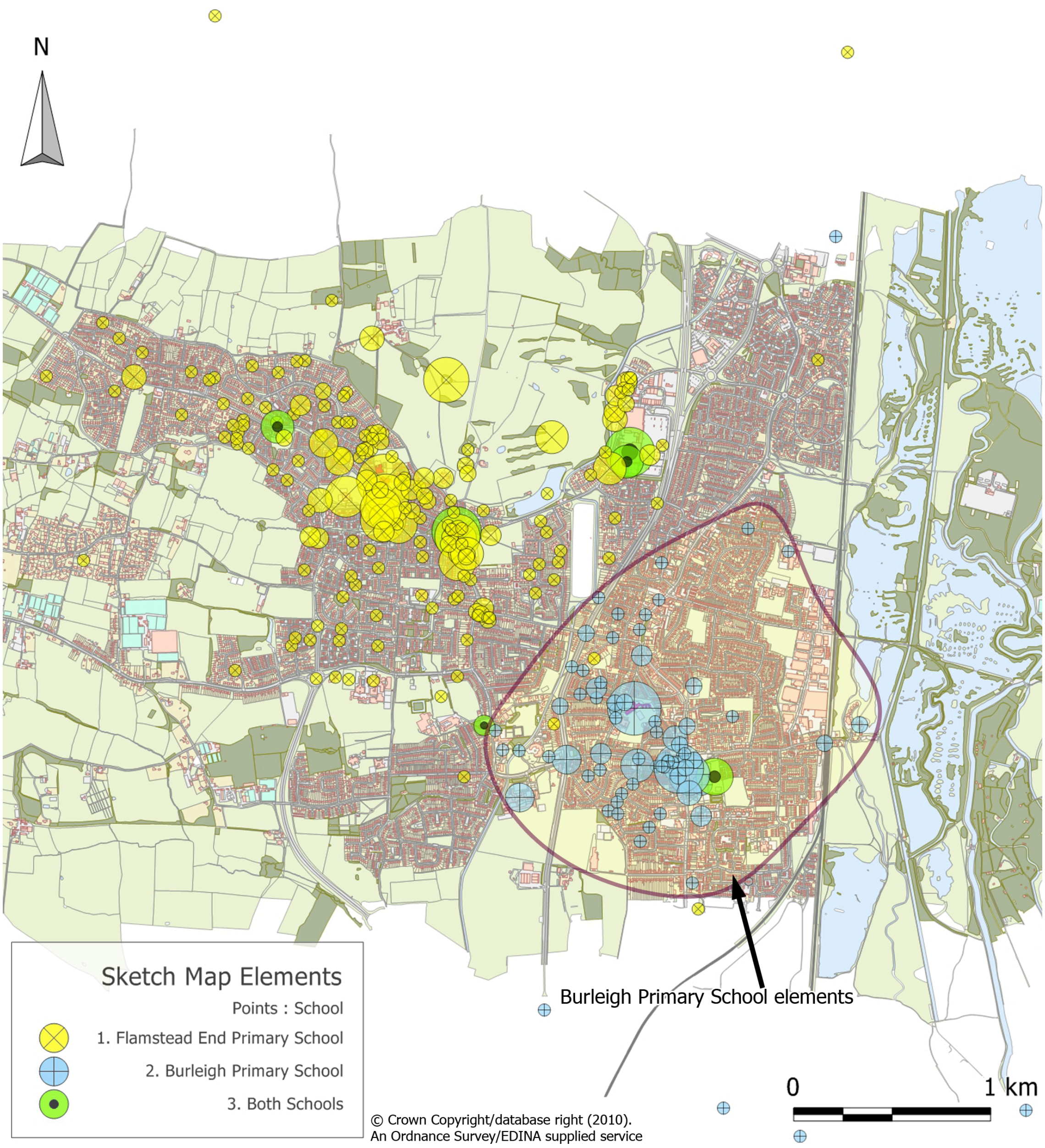


Figure 9-10: Map showing the area covered by the vast majority of points added by children at Burleigh Primary School

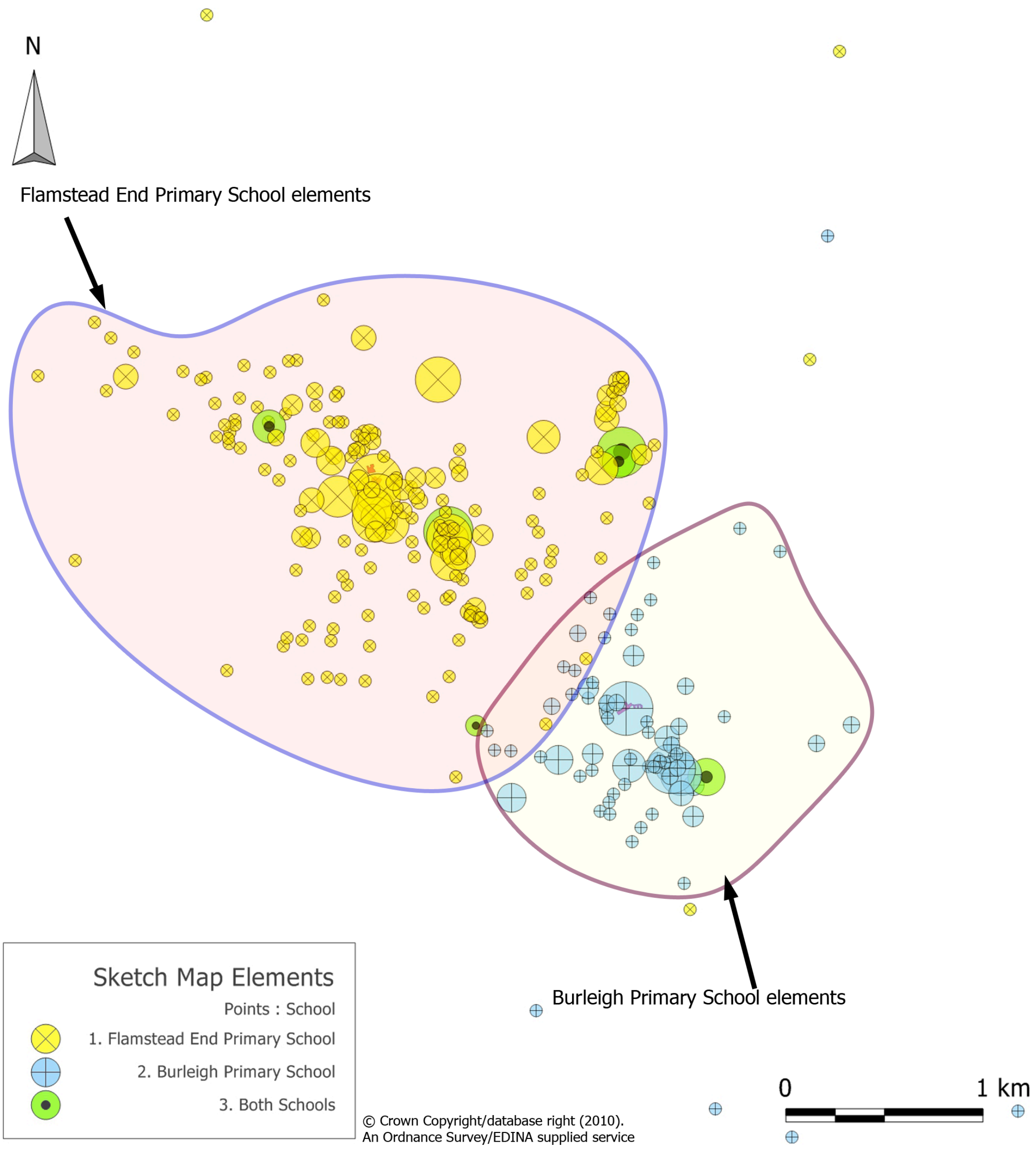


Figure 9-11: Comparison of he areas that include the majority of points for both schools

The areas covering the majority of points for each school are largely separate. There is only a slight overlap at the point where the western edge of the Burleigh area intersects with eastern side of the Flamstead End area.

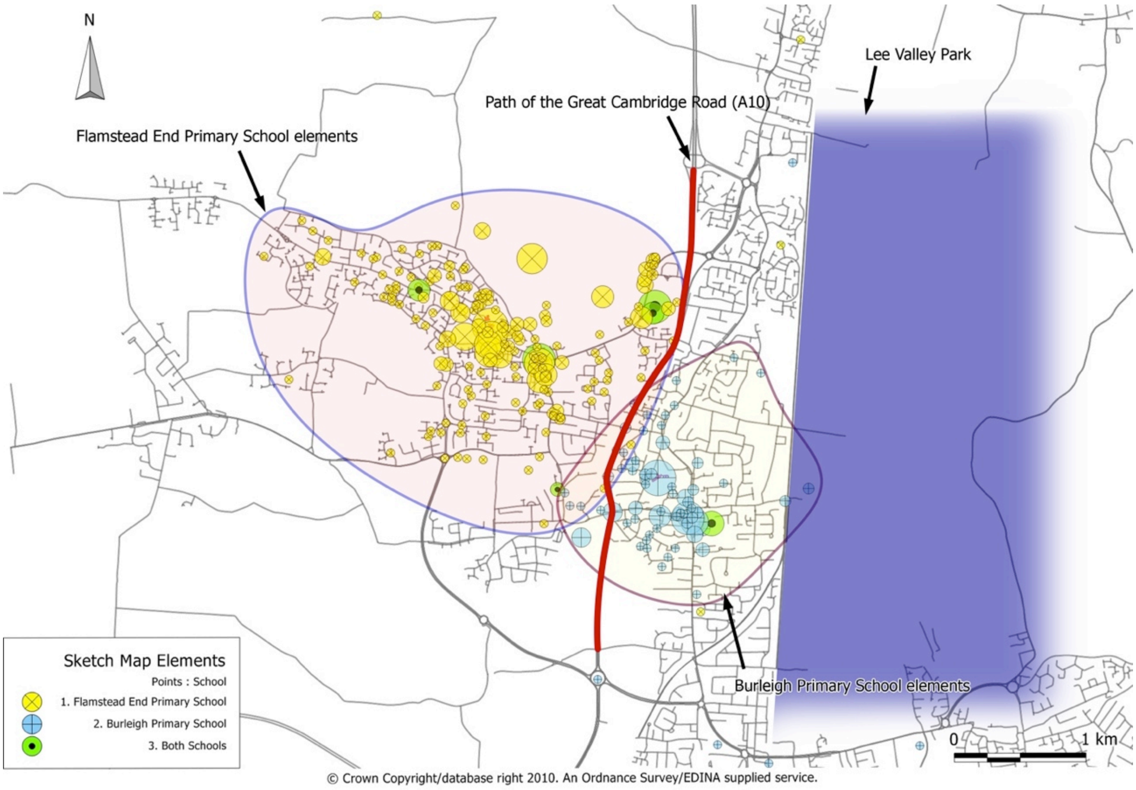


Figure 9-12: Map of the transport network in Cheshunt showing the placement of area sketch map elements

The map in Figure 9-12 shows the placement of the sketch map elements in the area maps for children at both schools. It can be seen that the clusters for the two schools are almost perfectly separated by the A10, also known as the Great Cambridge Road. The picture below, Figure 9-13, shows a picture of a busy stretch of the A10, the picture was taken by the author when walking between the two schools during a fieldwork visit.

Figure 9-13: Junction on the Great Cambridge Road (A10)

The A10 is a very busy road and it is not surprising that the children's experience of the local environment is divided by its presence.

9.4.1 Average element distances from the schools

It can be seen that the elements from the Flamstead End children cover a larger area than those of the children at Burleigh Primary. The table below, Table 9-5, shows the average distance of the elements from each school, calculated as a mean value of the each child's mean distance score.

Table 9-5: Mean of per child mean distance in metres

	Burleigh Primary Distance (m)	**Flamstead End Distance (m)**	**Both Schools Distance (m)**
Year 4	405.58	654.88	526.53
Year 5	.	508.68	508.68
Year 6	492.88	363.48	421.13
Total	**446.08**	**502.82**	**481.81**

The figures in Table 9-5, above are an average of an average, showing how the per child mean distance varies between year groups and between schools. More representative of the picture seen above in Figure 9-11, are the results given in Table 9-6, below, which average across all the recorded elements (without taking the first step of averaging for the child). The figures in table 9-6, below show the same kind of difference between the average distances for the two schools shown in Table 9-5: Flamstead End has higher average distances than Burleigh Primary.

Table 9-6: Mean real word distance (m)

Mean Real world distance (m)

	Boys	Girls	Grand Total
Burleigh Primary – all years	**448.3**	**497.7**	**474.8**
Burleigh Primary - Year 4	496.2	490.3	492.9
Burleigh Primary - Year 5			
Burleigh Primary - Year 6	411.6	504.3	459.8
Flamstead End – all years	**563.7**	**594.0**	**580.1**
Flamstead End – Year 4	736.2	616.0	677.6
Flamstead End – Year 5	618.3	595.1	604.5
Flamstead End – Year 6	403.3	580.0	494.5
Grand Total	**534.1**	**569.5**	**553.2**

Table 9-6 also suggests that mean element distance falls as children progress through the school years, a rather unexpected finding.

9.4.2 Differences in maximum distance represented in the area sketch map

The following graphs, Figure 9-14, compare the distributions of the distances to the furthest recorded location in the area sketch maps. The distances are measured between the school and the elements recorded in the map.

The results do not show a clear or consistent pattern over the years, or between the schools. The average distance for the Burleigh Primary children shows an increase with age, while for the children at Flamstead End it shows a decrease.

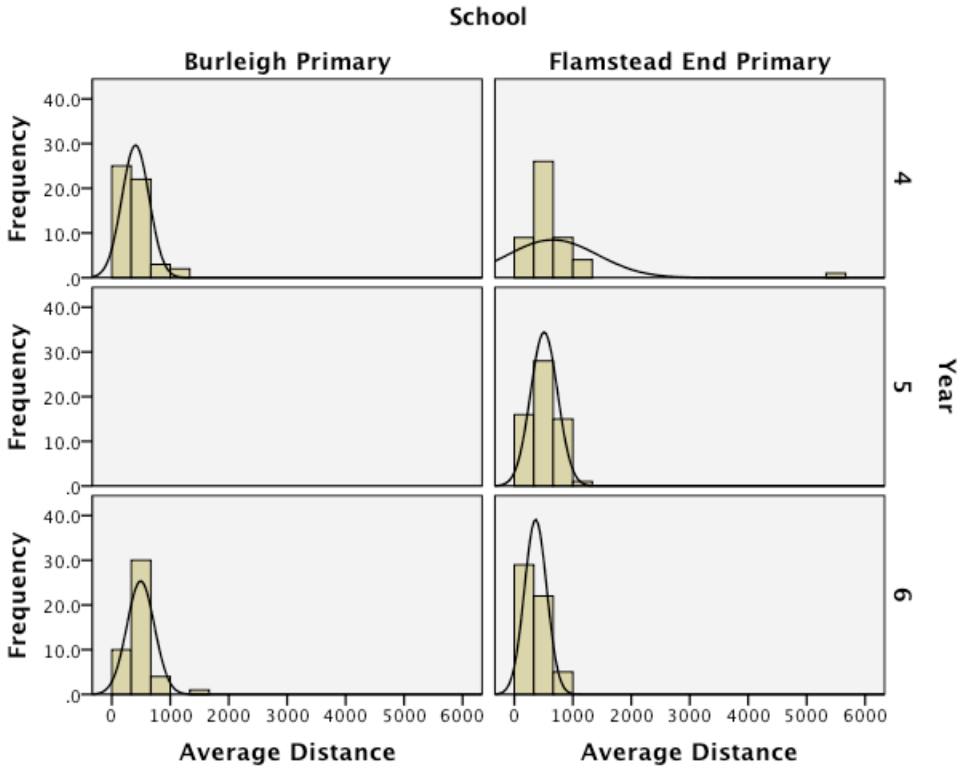


Figure 9-14: Distance of the furthest recorded point in the area sketch maps

It can be seen that there is an extreme outlier in the results for Flamstead End Primary School Year 4: one child has a maximum distance over 5.5km. Once this case has been removed, Figure 9-15, the histograms show a great deal of similarity between the distributions for the average distance represented in the area sketch maps.

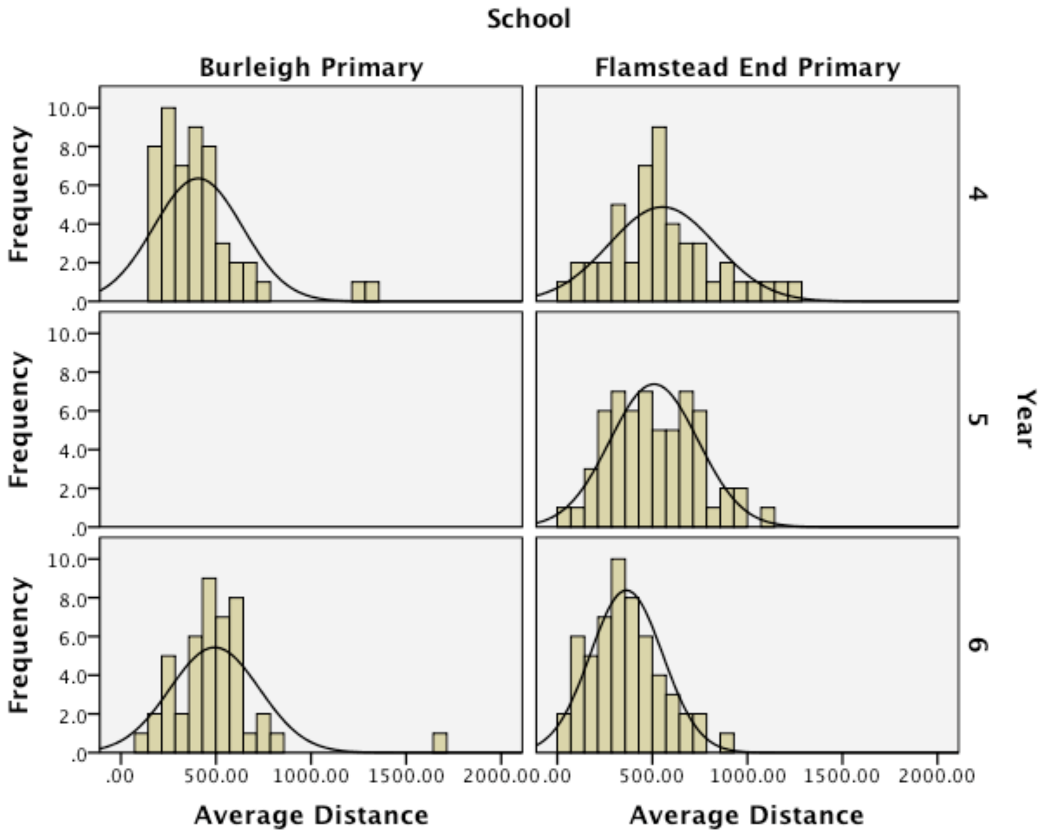


Figure 9-15: Distance to the furthest recorded element, after removing one outlier

Figure 9-16, shown below, presents histograms the average distance represented in the area sketch maps. Once again separate histograms are presented for each school and school year combination. In this figure there are separate histograms for boys and girls: the boy's data is shown in blue, and the girl's data is shown in green. There are no immediately obvious differences in the distributions for boys and girls.

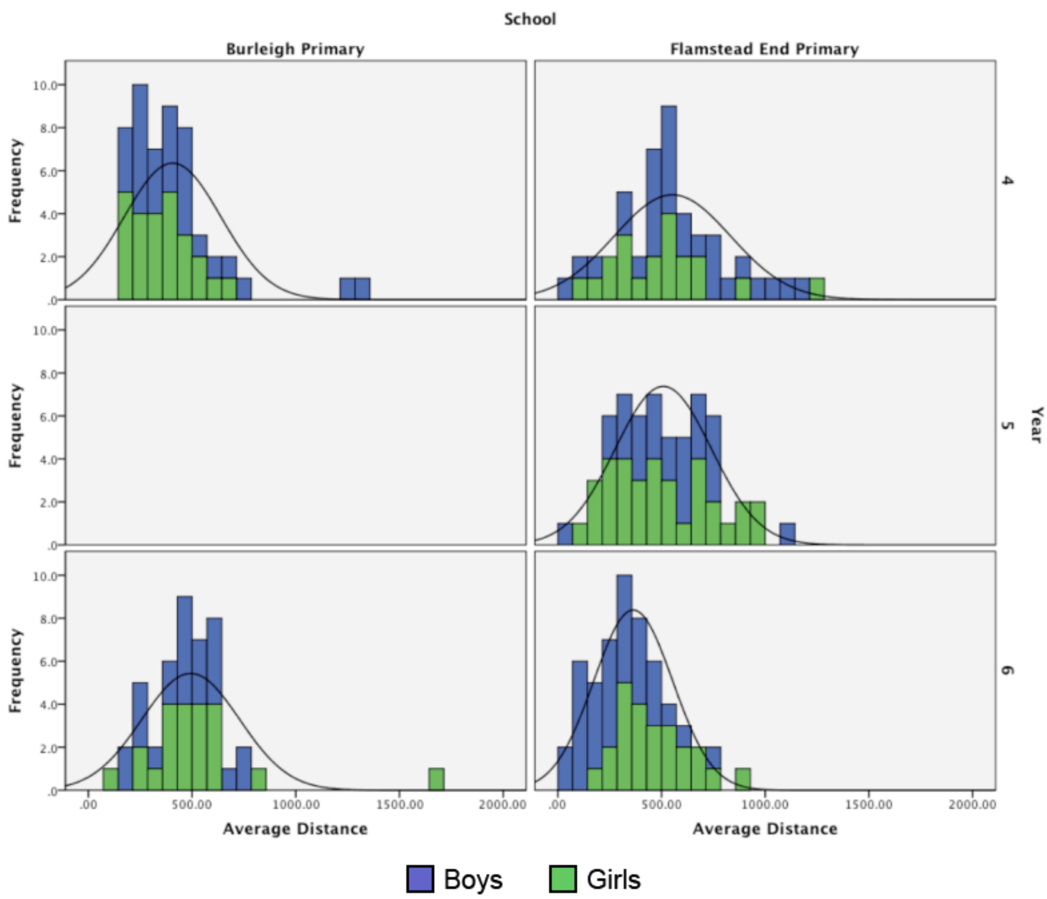


Figure 9-16: Comparison of the distribution of furthest points for boys and girls in the sample

9.4.3 Changes in average distance of sketch map elements

The graph below in Figure 9-17, shows the average distance figures for each year at both schools. Both schools show a different pattern. Surprisingly the clearest pattern is the decrease in average element distance for the children at Flamstead End. It might have been expected that as the children progressed through the school years the distance of the furthest point would increase.

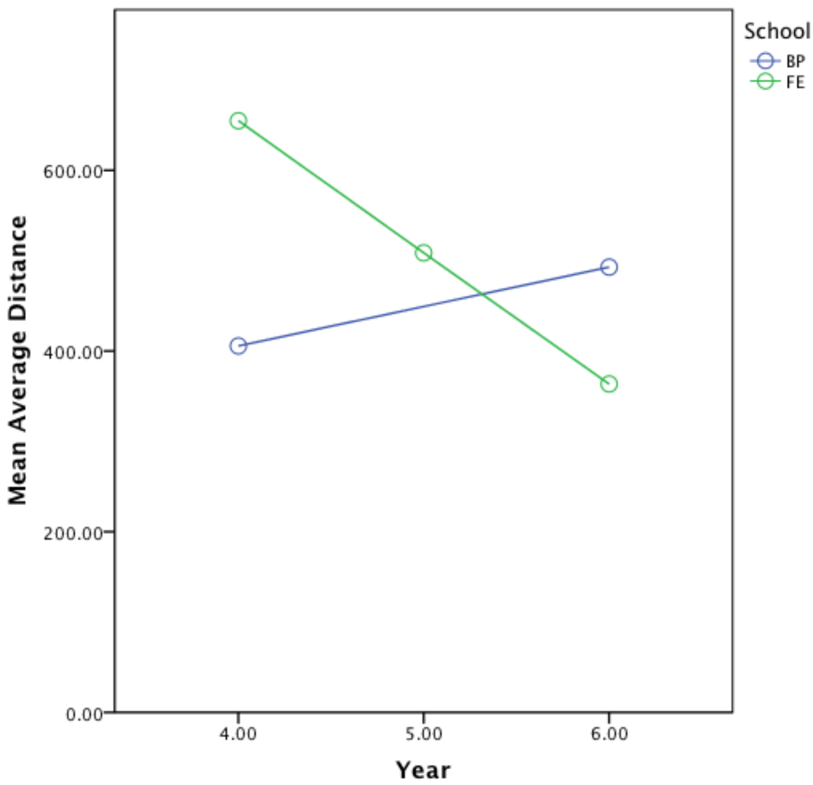


Figure 9-17: Average distance of the elements represented in the children's area sketch maps

9.5 Detail in the area sketch maps

9.5.1 Analysis of the number of elements included in the area sketch maps

The picture for the number of elements included in the children's sketch maps is much more straightforward. The graph in Figure 9-18, which shows number of elements included in area sketch maps against school year, shows a clear upward trend. The overall pattern is that the higher the year group, the more elements are included in the map, this pattern is broken by the performance of the children in Year 5 at Flamstead End who record slightly more detail than the children in the next year up in Year 6.

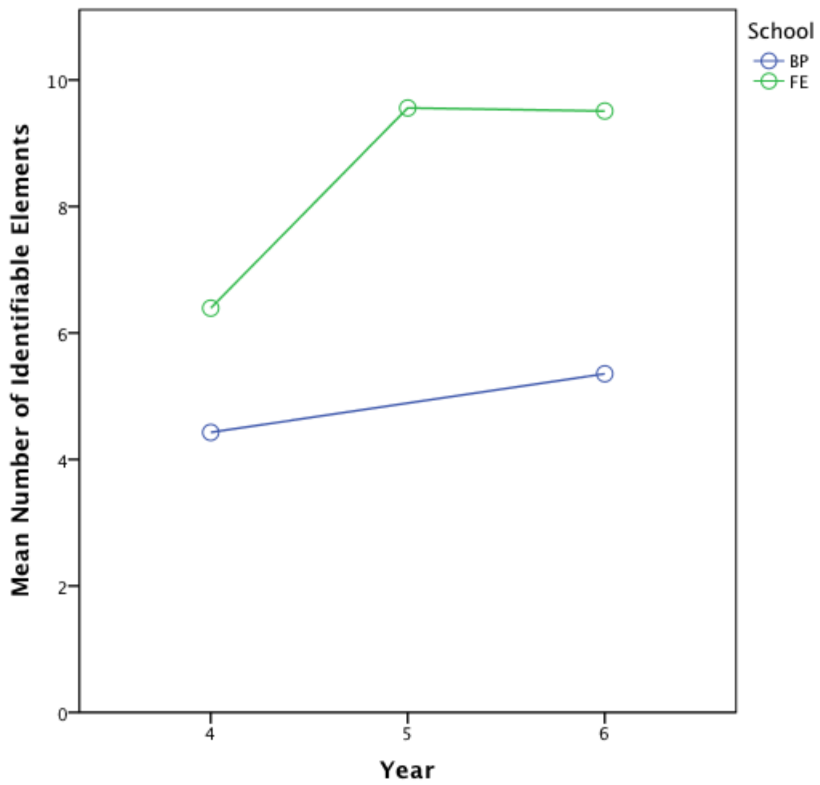


Figure 9-18: Average number of elements represented in area sketch maps by school and school year

There is also a clear difference between the two schools, children at Flamstead End record many more elements by the time the reach Years 5 and 6 compared with Year 4.

9.6 Detail in area sketch maps

Figure 9-19 is a histogram showing the distribution of the number of elements included in the sample. The number of elements ranged from 2, found on two maps, up to 19 elements, which was only found in a single case. The mode for the element distribution was 4, and 33 of the area sketch maps included 4 elements.

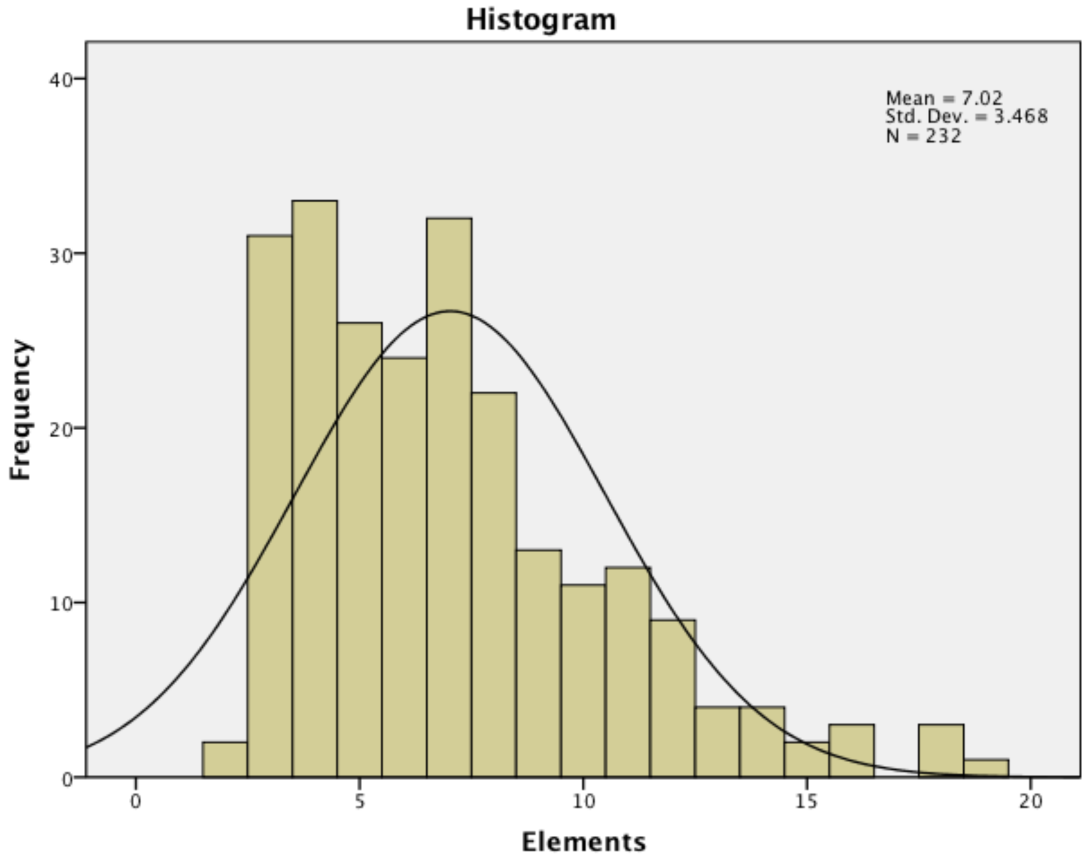


Figure 9-19: Histogram showing the distribution of number of elements included in an area sketch map

The distribution in Figure 9-19 appears to be bimodal, with peaks at 4 and 7 elements. It appears that this is due to a difference between the two schools. Figures 9-20 and 9-21 show the element distributions for the individual schools, and it is clear that the original distribution is in fact made up of two separate distributions, one, Burleigh Primary School, with a mode of 4, and another, Flamstead End Primary School, with a mode of 7.

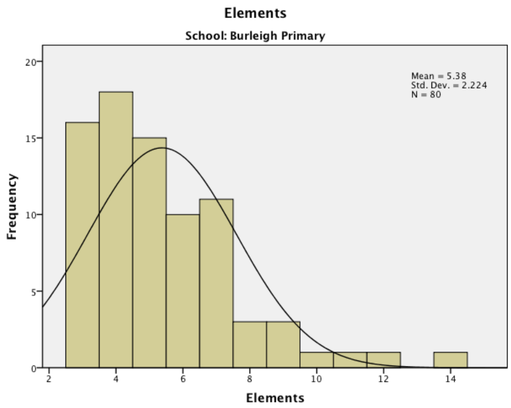


Figure 9-20: Histogram showing the distribution of the number of elements recorded by children at Burleigh Primary School

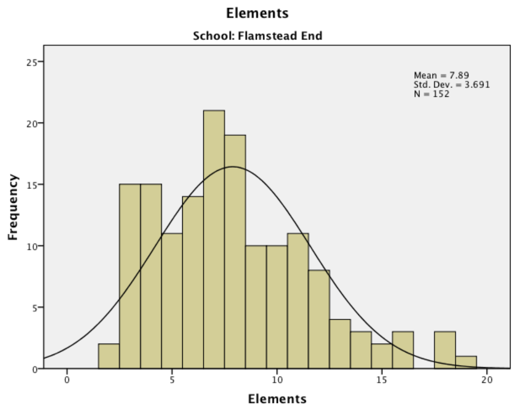


Figure 9-21: Histogram showing the distribution of the number of elements recorded by children at Flamstead End Primary School

The difference in number of elements recorded at the two schools is significant; children at Flamstead End Primary School recorded significantly more elements than children at Burleigh Primary School (t = 6.5, df = 225.8, $p < 0.0005$, two-tailed, equal variances not assumed).

It can be seen from the histograms of element frequency that the distributions are not symmetrical. The overall distribution, and the distribution for Burleigh Primary have obvious positive skews: the means in both cases are above the modes. The distribution for the elements at Flamstead End also has, a very slight, but still positive skew.

9.6.1 Examples of high and low element sketch maps

Figures 9-22 and 9-23, below, show maps that contain 2 and 19 elements respectively. The figure for elements represents the number of unambiguously identifiable elements present in the sketch maps. All of the area maps were centred on the school, and the school was included as an element for all maps, and given the coordinates 0,0 in both configurations (sketch map and real world).

The other identifiable element in Figure 9-22 (left), is the roundabout below the school. Although this is not clearly labelled, it was felt to be reasonable to assume which real world element it referred to. The shops and car park also shown could have referred to many different locations and were, therefore, not included in the analysis. More detail about the process of matching sketched and real world locations can be found in Chapter 6.

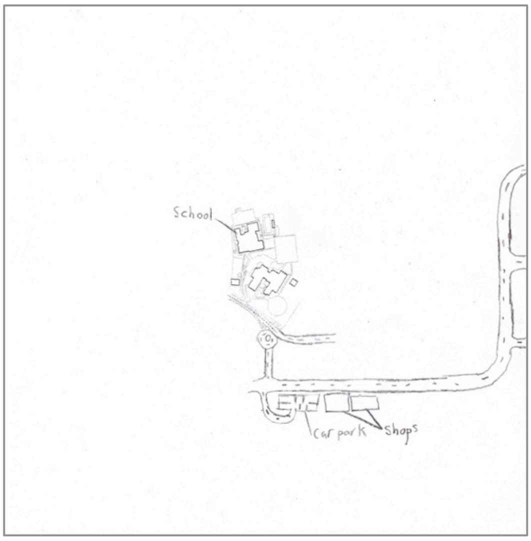


Figure 9-22: Area sketch maps with 2 identifiable elements (FE4-005) – *Note FE4-041 also contains 2 usable elements*

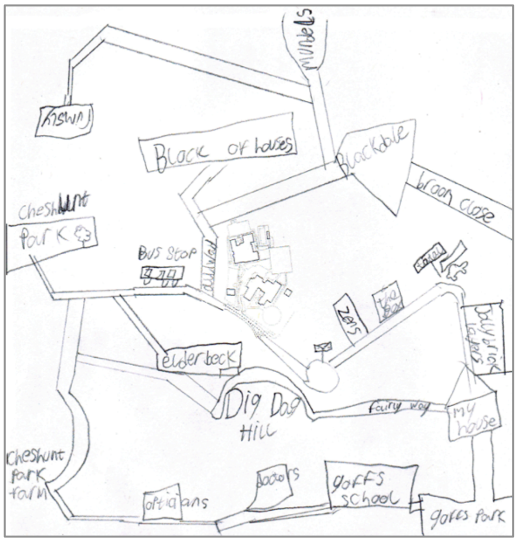


Figure 9-23: Area sketch map with 19 identifiable elements (FE5-012)

9.7 Chapter summary

As each child could choose which elements to include, provided they could bring them to mind, the elements, and the number included show a great deal of variation. The number of included identifiable elements ranges from 2 to 19. In addition there one map that included no identifiable elements, this was excluded from the analysis.

When examining the spatial distribution of the elements in the children’s area sketch map, there is a clear difference between the two schools. There are very few elements that are used by children at both schools. It is clear that, rather than forming one large Cheshunt sample, the children form two school-based samples. It is suggested that the lack of overlap is partly due to the very busy road that runs between the two schools.

Children at Flamstead End Primary School recorded significantly more detail than children at Burleigh Primary School. Overall Burleigh Primary School maps represent a smaller area, but children in Year 6 at Burleigh Primary School cover a larger area than children in the same year at Flamstead End Primary School.

10 Area sketch map accuracy

10.1 Variation of sketch map DI (Distortion Index) by sex and school year

The main outcome measure in this research is the level of distortion present in the child's area sketch map, given by the value of DI (distortion index). The DI score is being used as a proxy for the distortions present in the child's cognitive representation of the area around the school.

DI is calculated using bidimensional regression (the technique is described in detail above in Chapter 6). DI is a measure of the distortion found to be present in the area sketch map when it is compared to the real world. The area sketch map was the result of the area sketch mapping task. This task asked children to make their best effort to recall and represent the position of landmarks in the local environment, that is the environment around their school (where the children were located when drawing the map). Increasing levels of DI indicate increasing levels of distortion, or lower levels of accuracy. Table 10-1 shows the mean and standard deviation for the unweighted values of area map DI for boys and girls in different school years.

Table 10-1: Unweighted means for DI (distortion index) scores for children's area sketch maps

		Year 4	Year 5	Year 6	All years
Boy	Mean	65.0	65.2	50.6	59.6
	SD	*24.1*	*20.2*	*20.9*	*23.0*
Girl	Mean	69.4	65.6	61.4	65.5
	SD	25.1	19.6	23.3	23.0
Both	Mean	67.0	65.4	55.7	62.4
sexes	*SD*	*24.5*	*19.7*	*22.6*	*23.1*

10.2 Weighting accuracy results by map detail

The comparison between the sketch map and the real world map is made on the basis of the landmarks that are included on the sketch map. Detail in the map is assessed by counting up the number of unambiguously identifiable elements that the child had included in the map, see Chapter 9. Each child's area map DI value was calculated from the configuration of points that was included in his or her map, so the value for detail is also the number of points used to calculate the map's DI value. Table 10-2 shows the means and standard deviations for the number of points recorded in the children's maps, by child's sex and school year.

Table 10-2: Detail represented in the children's area sketch maps

		Year 4	Year 5*	Year 6	All years
Boy	Mean	5.1	7.8	7.0	6.4
	SD	*2.4*	*3.7*	*3.0*	*3.2*
Girl	Mean	6.1	8.8	8.3	7.7
	SD	2.9	*3.7*	*3.8*	*3.7*
Both	Mean	5.5	8.4	7.6	7.0
sexes	*SD*	*2.7*	*3.7*	*3.5*	*3.5*

* The peak in map detail in year 5 is discussed in more detail below.

Without any adjustment for detail, maps that included 2 points would be treated with the same weight as those have 19 points, the minimum and maximum number, respectively, of elements included the children's area maps.

It can be argued that a child makes his or her task more difficult with every element that is added to the map. Each extra point increases the chance that they will distort the configuration of elements, thereby reducing the accuracy of the representation.

This is illustrated in Figure 10-1, below, this figure shows the map with the lowest DI in the sample. The map is one of the least complete maps, featuring only 2 elements: the main school building and a roundabout. The map also shows a nursery and a playing field, it is likely that these are other areas of the child's school, in very close proximity to the classroom, and they were not included in the analysis. Not only does the map feature a very low element count it also has the lowest possible DI of 0.

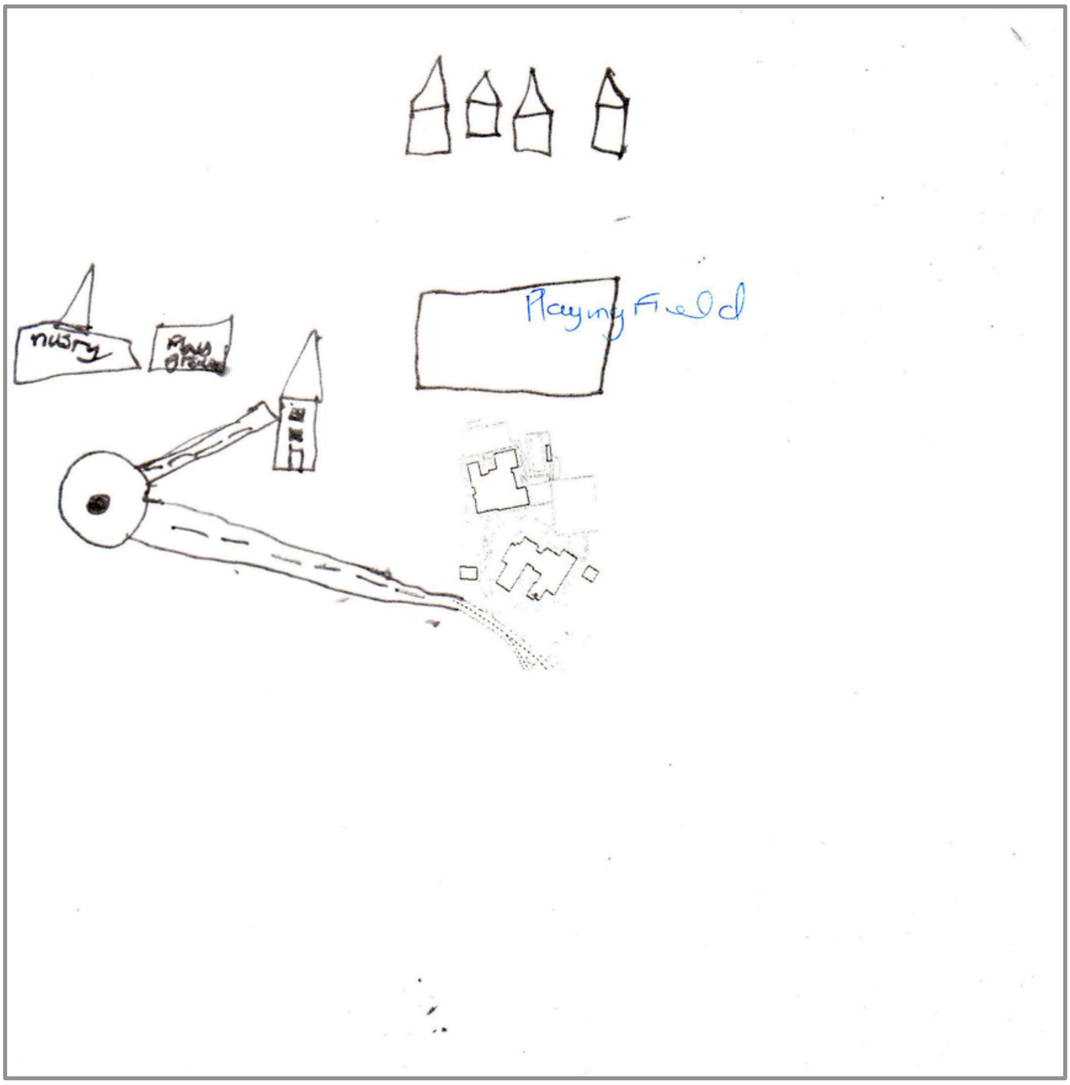


Figure 10-1: Area map with the lowest value of DI, this map also has the lowest number of identifiable elements (FE4-041)

The map shown below in Figure 10-2, has the highest value of DI found in the sample (99.9).

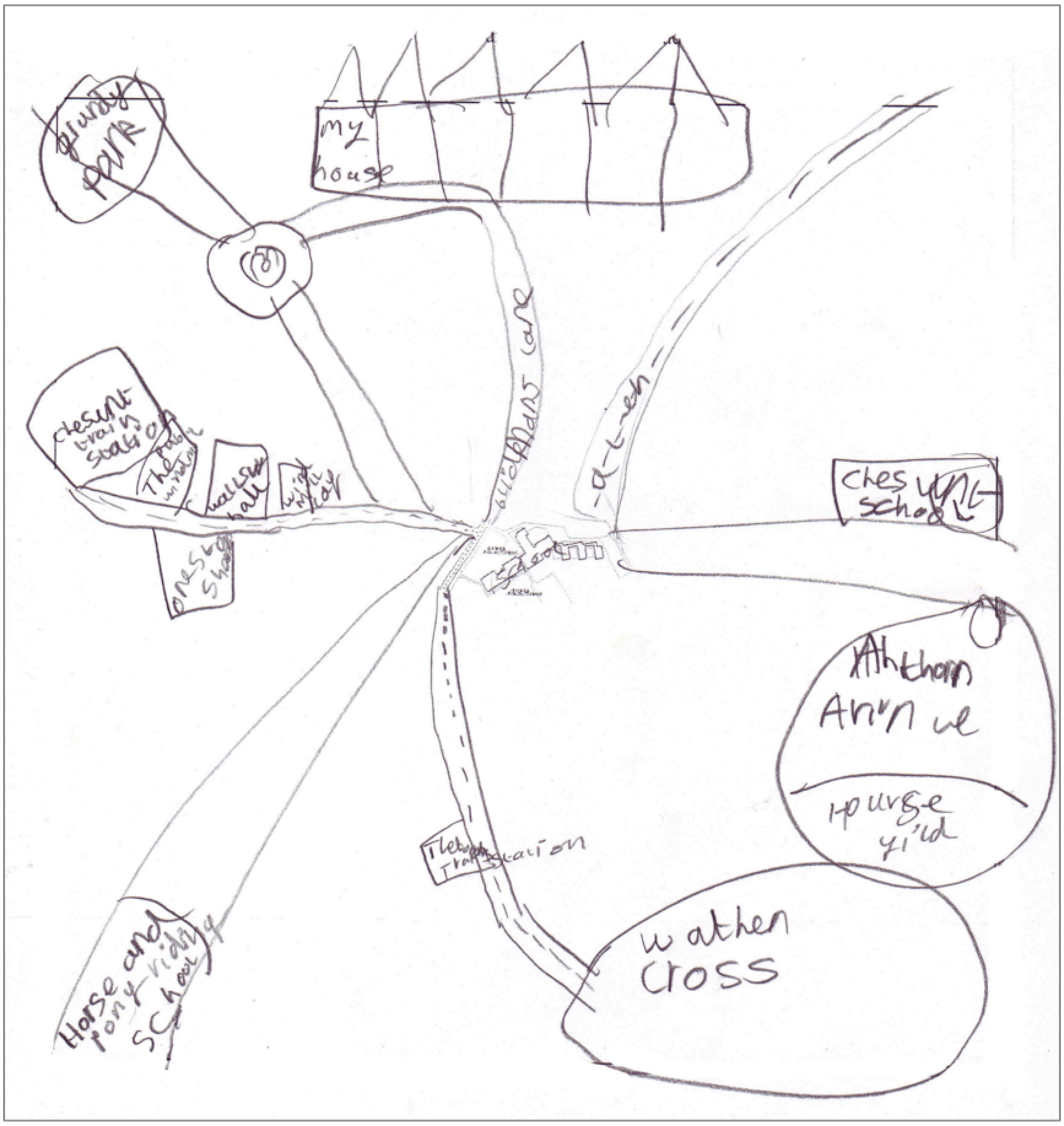


Figure 10-2: Area map with the highest value of DI, this map has 9 elements (BP4-047)

The area sketch map with the most identifiable elements (FE6-043), shown below in Figure 10-3, has a high value for DI (74.3). If there was a straightforward relationship between detail and accuracy, it might be possible to raise some objection to the weighting of the accuracy scores with the detail measures. From the inspection of the measures for the maps shown above, there does not seem to be a straightforward positive relationship between detail and accuracy.

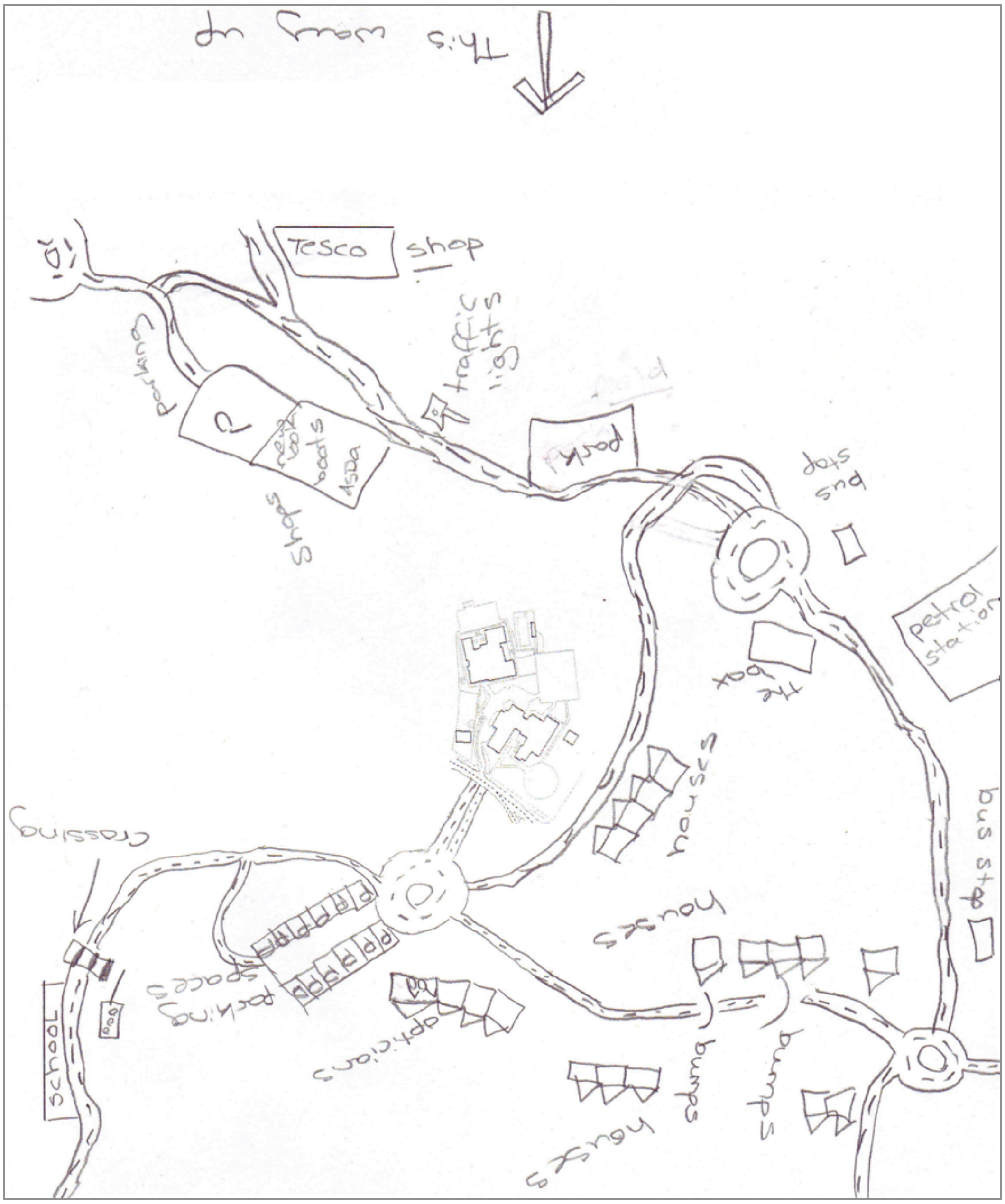


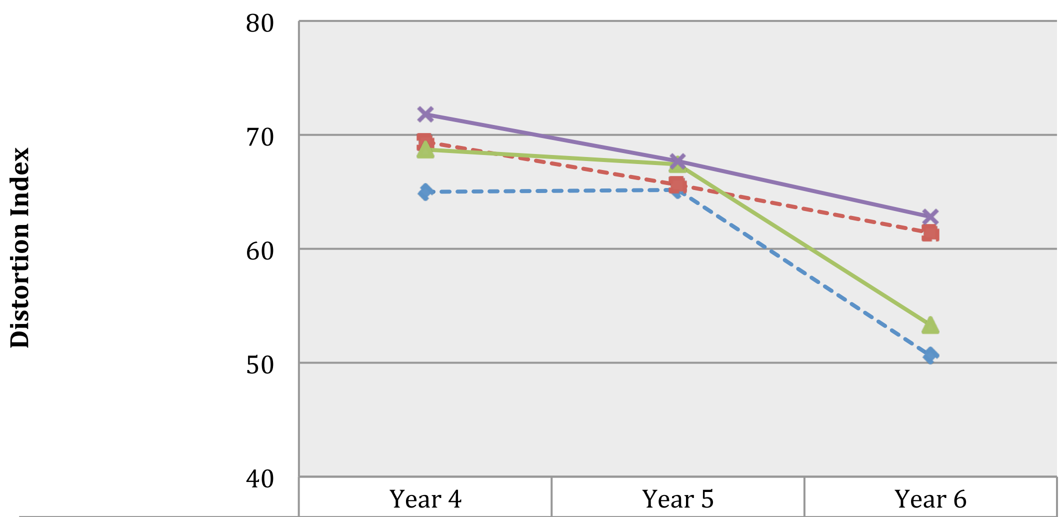
Figure 10-3: The sketch map with the greatest number of elements (FE6-043) also has a high value for distortion index (74.3)

However, if we consider all of the area maps in the sample, there does appear to be a modest relationship between detail and accuracy, there is, a modest significant positive correlation between DI and element count ($r = 0.19$, N = 232, $p = 0.004$, two–tailed).

But rather than increasing the strength of this positive correlation, weighting the sample based on the number of elements actually has the effect of reducing the strength of the positive correlation between DI and element count ($r = 0.097$, N = 1629, $p < 0.0005$, two–tailed). It should be noted that the value for N given in the weighted correlation is far higher than that given for the unweighted correlation. Applying the weighting to the sample effectively changes the N values in the reported statistics into a measure of elements, rather than a measure of the number of children.

Weighting of the sample in this way gives more prominence to maps that are more complete, cases where a child has made a better attempt at representing the local environment. It also allows two important descriptors, the detail and accuracy of the maps, to be considered at the same time. The weighting will be employed in subsequent analyses of DI scores.

Figure 10-4 compares the original (unweighted) and weighted values for mean DI scores for boys and girls over the three school years included in the sample. It can be seen that the values of the weighted (shown by the solid lines) and unweighted (shown by the dotted lines) scores are very similar.



	Year 4	Year 5	Year 6
Boys	65	65.2	50.6
Girls	69.4	65.6	61.4
Boys(weighted)	68.7	67.4	53.3
Girls (weighted)	71.8	67.7	62.8

Figure 10-4: Graph and table comparing mean unweighted DI scores with mean DI scores weighted by element count.

It can be seen from Figure 10-4 that in both sexes the unweighted value of DI tends to decrease between Year 4 and Year 6.

10.3 Detail recorded in children's maps

An Analysis of Variance (ANOVA) was used to investigate how number of elements varies between boys and girls and by school year. Figure 10-5 shows the mean number of identifiable elements included in the children's sketch maps by school year, the graph shows separate lines for boys and girls. It is apparent from the graph that girls consistently record more elements than boys in their sketch maps.

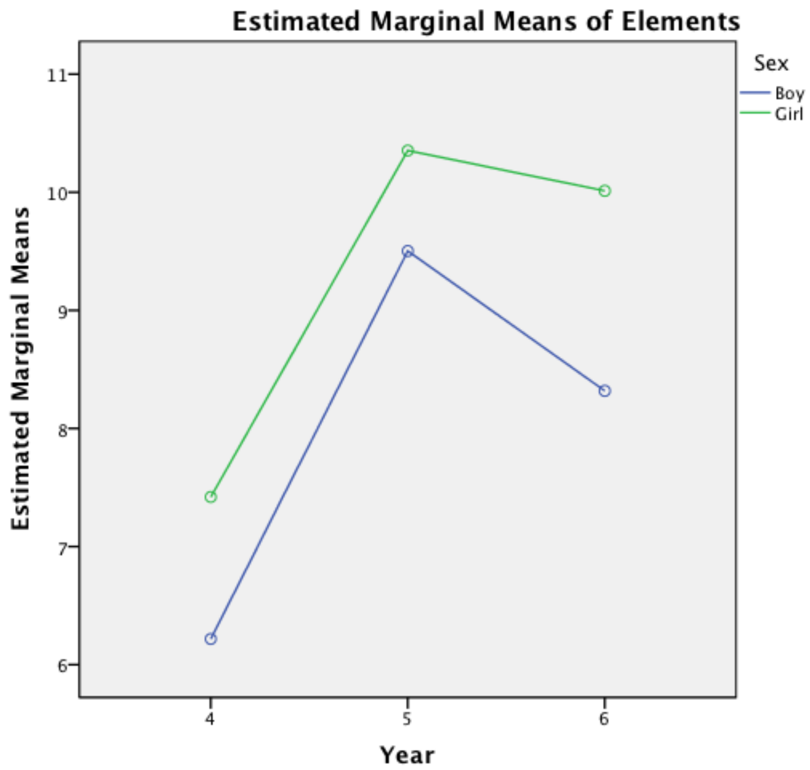


Figure 10-5: Mean number of elements included in a sketch map by sex and school year for children at both schools

Both sexes share the peak in elements in Year 5, this is a product of the missing Year 5 data from Burleigh Primary, together with the fact that children in Flamstead End tend to record more detail in all year groups. Table 10-3 compares the number of elements recorded by children at both schools.

Table 10-3: Comparison of element counts for Burleigh Primary School and Flamstead End Primary School

			Burleigh Primary	Flamstead End
Year 4	Boys	Mean	4.5	6.5
		SD	*1.5*	*2.9*
	Girls	Mean	5.7	8.8
		SD	*2.2*	*3.9*
Year 5	Boys	Mean	-	8.9
		SD		*3.9*
	Girls	Mean	-	10.5
		SD		*4.0*
Year 6	Boys	Mean	6.1	9.1
		SD	*2.1*	*3.8*
	Girls	Mean	6.4	11.8
		SD	*3.1*	*4.7*

It can be seen from Table 10-3 (shown above) that the number of elements within each school follows a clear progression: increasing mean element counts as school year increases. The higher scores for girls are present in every combination of school and school year.

10.4 Effect of travel mode on the quality of area sketch maps

The following analyses will investigate how the quality of area sketch maps is affected by the amount of time spent walking and the amount of time spent travelling by car. In the first graph, Figure 10-6 shown below, the DI (area map distortion index) is plotted against the overall duration of car travel. Also included in the graph are linear and logarithmic fit lines.

10.4.1 Accuracy and the time spent travelling by car

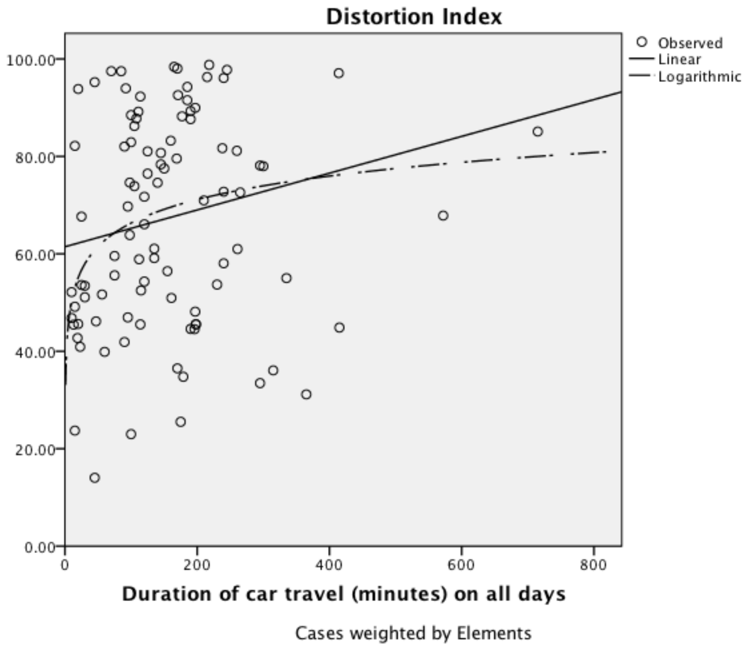


Figure 10-6: Area map distortion index plotted against overall duration of car travel

Both linear and logarithmic fits are significant: Linear fit, $R^2 = 0.41$, $p < 0.0005$; Logarithmic fit $R^2 = 0.095$, $p < 0.0005$. See Figure 10-7, below for a plot of DI against the natural log of car travel duration.

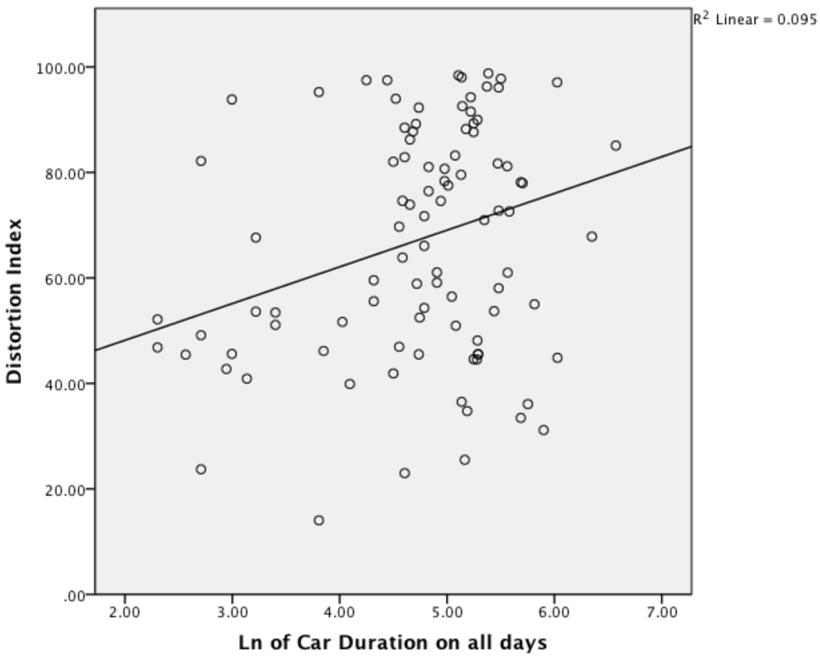


Figure 10-7: Area map distortion index plotted against overall duration of car travel

Table 10-4: Correlation between DI and time spent in car travel

	Correlation with DI (2 s.f.)	*N*	*p*
Duration of car travel (minutes) weekdays only	0.10	743	0.005
Duration of car travel (minutes) weekends only	0.13	743	0.001
Duration of car travel (minutes) on all days	0.17	743	< 0.0005

The duration of car use has a small positive correlation with DI (see Table 10-4), all the correlations are highly significant.

10.4.2 Accuracy and the time spent travelling by walking

The duration of walking does not show any significant correlations with DI (see Table 10-5). This is possibly because the amount of walking, by both duration and the number of children who do any walking at all, is much smaller than the amount of car use.

Table 10-5: Correlation between DI and time spent walking

	Correlation with DI (2 s.f.)	*10.4.2.1.. *	*p*
Duration of walking (minutes) weekdays only	-0.033	743	0.36
Duration of walking (minutes) weekends only	0.059	743	0.11
Duration of walking (minutes) on all days	0.027	743	0.47

10.5 Investigating the influence of travel mode on cognitive distortions

The levels of distortion in children's cognitive maps were compared based on the relative amount of time the children spend walking or as car passengers. Two comparisons were made, the first compared children who spent more time walking than they did as car passengers for days during the week, the second comparison was the same except that it considered duration of travel at the weekend.

In the following comparison the dependent variable was map score, which is simply a reversed version of DI (distortion index). DI scores run from 0 to 100 and the map score is obtained by taking the DI score away from 100. Map score is used instead of DI for clarity and to match the previous measures of cartographic competence which increased as competence increased.

The dependent variable of map score will be weighted by the number of elements, as described in the previous section to combine the detail and accuracy measures of the children's maps.

Table 10-6: Dominant mode for weekdays and days at the weekend for children in the Cheshunt schools

		Walk more than use car (weekday)		Walk more than use car (weekend)	
		Yes	No	Yes	No
Burleigh Primary	Year 4	10	12	5	17
	Year 5				
	Year 6	7	7	1	13
Flamstead End	Year 4	6	15	1	20
	Year 5	8	22	4	26
	Year 6	5	11	1	15

It can be seen from Table 10-6, above, that some of the categories contain very few children. Apart from the missing data for children in Year 5 at Burleigh Primary, there are also very small numbers of children at the weekend who spend more time walking than they do in the car. For this reason it has been decided not to consider the schools separately in the following ANOVA models. Table 10-7 shows the numbers of children in the mode based groups when the schools are combined.

Table 10-7 : Dominant mode for weekdays and days at the weekend, both schools considered together

	Walk more than use car (weekday)		Walk more than use car (weekend)	
	Yes	No	Yes	No
Year 4	10	33	10	33
Year 5	5	25	5	25
Year 6	3	27	3	27

Figures 10-8 and 10-9, below, show the mean weighted map scores across the three school years, there are separate lines for children whose dominant mode is walking (shown in green), and children whose dominant mode is car travel (shown in blue).

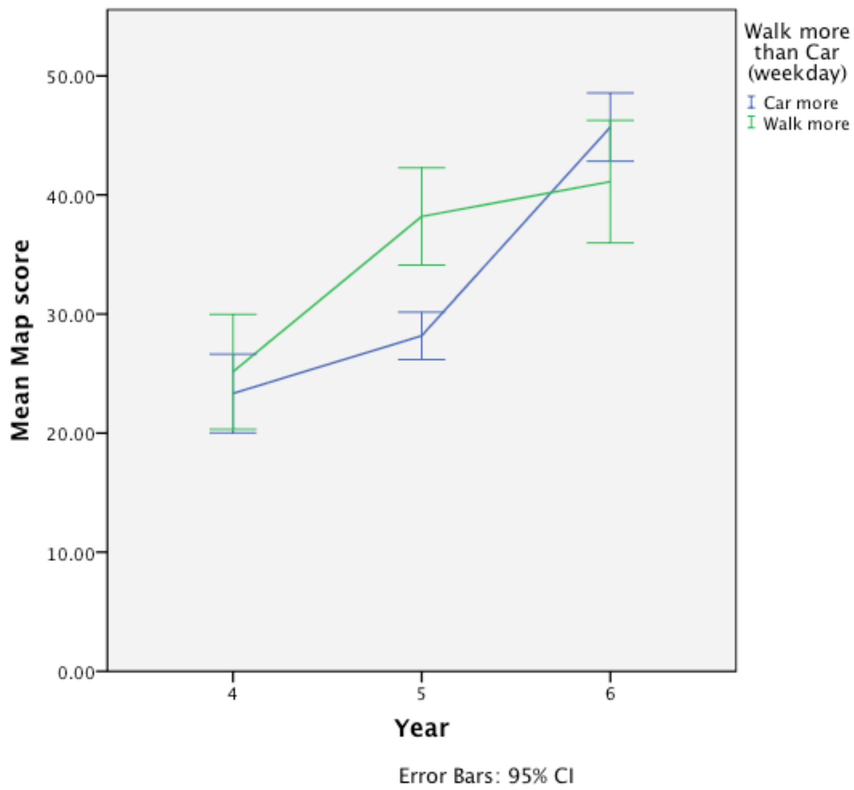


Figure 10-8: Mena map score by dominant mode during the week

Figure 10-8 above shows the expected increase in map score as children get older, but there is no clear advantage for either dominant mode. When considering the situation at the weekend, Figure 10-9, there is a clear advantage for children whose dominant mode is walking.

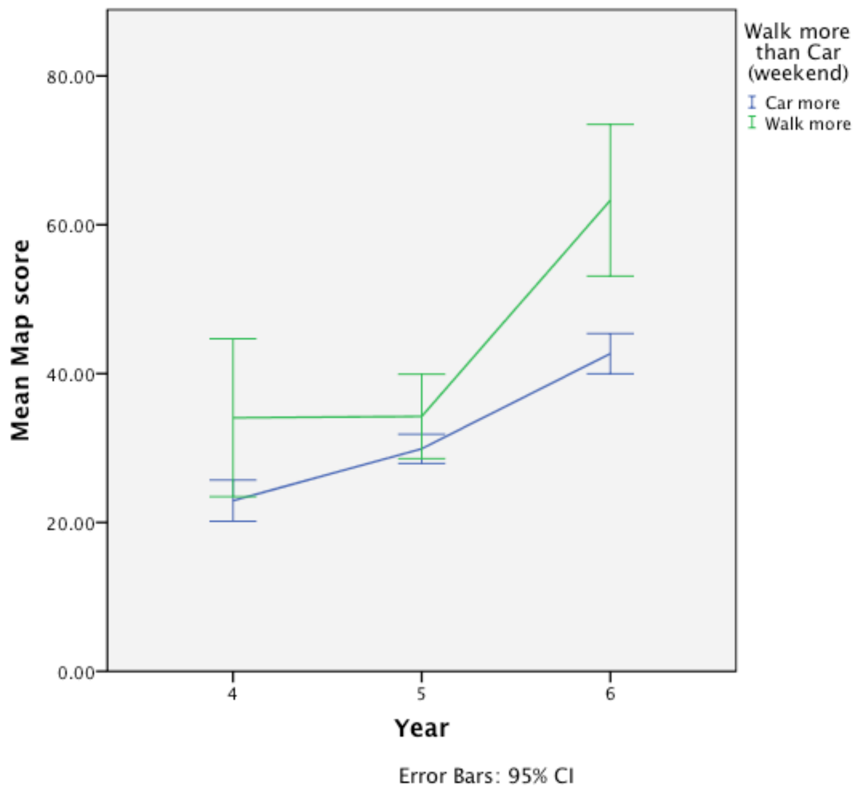


Figure 10-9: Map score by dominant mode during the weekend

10.6 ANOVA for map score

Using a general linear model allows for the factors for child's sex (2 level), school year (3 level) and dominant mode (2 level: walk or car) to be considered at the same time. Dominant mode will be considered across all days, there will be no distinction between weekday and days at the weekend.

The 3*2*2 ANOVA for School Year*Dominant Mode*Sex reveals significant main effects for school year and dominant mode. Sex of the child was not a significant factor. Table 10-8 and 10-9 below show the F ratios and *p* values for the main effects (Table 10-8) and interactions (Table 10-9).

Table 10-8: Main effects in the ANOVA model for map score

Main effects	F	*p*
Dominant mode	$F_{(1, 731)} = 19.0$	0.004
Year	$F_{(2, 731)} = 39.5$	< 0.0005
Sex	$F_{(1, 731)} = 2.8$	0.097 (N.S.)

Table 10-9: Interactions in the ANOVA for map score

Interactions	F	p
Sex * Year	$F_{(2, 731)} = 15.2$	< 0.0005
Sex * Dominant mode	$F_{(1, 731)} = 14.3$	< 0.0005
Year * Dominant mode	$F_{(2, 731)} = 5.5$	0.004
Sex * Year * Dominant mode	$F_{(2, 731)} = 2.4$	0.092 (N.S.)

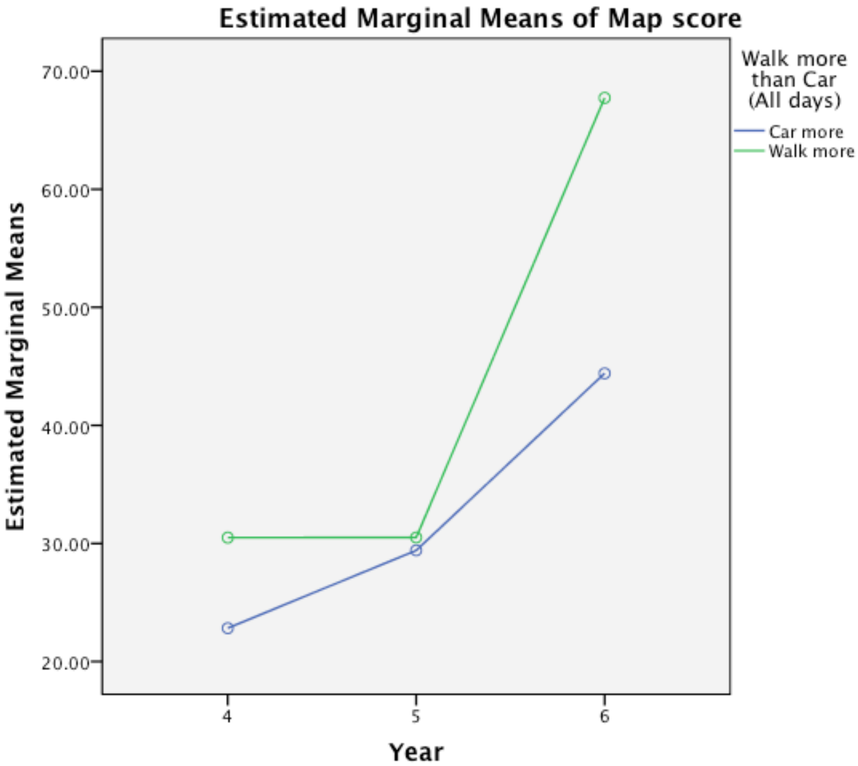


Figure 10-10: Mean weighted map score for walk and car against school year

The graph shown in Figure 10-10, see above, shows the mean weighted map scores for children with different dominant modes against school year. The familiar pattern of increasing map quality, this time measured in terms of accuracy, is evident. The walk group shows an interesting pattern of increase: there is almost no change between Year 4 and Year 5, but this is followed by a large increase up to Year 6. The children in car group show a more straightforward, if less dramatic, increase from year to year.

10.7 Regression models considering all activities undertaken by children

Multiple regression was used to investigate the contribution of time spent in different activities on the children's map scores weighted by detail (the dependent variable). The model includes factors for the child's sex, their age in years, the school they attend and the duration of the different types of activities that the child takes part in. The regression produced a weak fit ($R^2_{adj} = 0.21$), but the overall relationship was highly significant ($F_{(18,717)} = 11.4$, $p < 0.0005$) and the values of the coefficients in the model allow a closer examination of the relative contribution of the different factors to the overall measure of map score.

Before considering the contribution of the different factors, it should be noted that the low value for adjusted R^2 indicates that the factors in the model make up only a small part of the explanation for the accuracy of children's area sketch maps. This is perhaps not surprising as variation in the quality of cognitive maps, and the ability to recall the information that they contain, is influenced by a large variety of factors, only some of which are under examination here.

Table 10-10: Coefficients for factors included in a multiple regression model for weighted map score, all durations are in minutes

Factor	B	Beta
Age	5.96	2.84***
School (Burleigh Primary = 1 and Flamstead End = 2)	-10.27	-2.12***
Duration – Own Home (weekdays)	-0.02	-0.22***
Duration – Unstructured Activities (weekdays)	0.07	0.15***
Duration of car travel (weekends)	0.03	0.15***
Duration – Structured Activities (weekend)	0.04	0.11***
Duration – Non Home with Parent (weekends)	-0.02	-0.10*
Duration of car travel (weekdays)	-0.06	-0.14**
Duration – At Another Home (weekdays)	0.00	-0.02
Duration – Structured Activities (weekdays)	0.00	0.00
Duration – Unstructured Activities (weekend)	0.00	0.01
Duration of travel by walking (weekends)	0.00	0.00
Sex (Boy = 1 and Girl = 2)	-0.73	-0.02
Duration – Own Home (weekends)	0.00	0.05
Duration – Non Home with Parent (weekdays)	0.01	0.03
Duration of travel by walking (weekdays)	-0.03	-0.05
Duration – At Another Home (weekends)	0.00	0.00

* Significant at $p < 0.05$; ** Significant at $p < 0.005$; *** Significant at $p < 0.0005$

It can be seen from the Beta values in the table above (Table 10-10) that the factor that explains the most variation in this sample is the child's age. Increasing age leads to a higher map score, reducing the level of distortion recorded in the child's map. If all other things were equal, each additional year increases the child's map score by around 6. Interestingly the sex of the child is not significant, this suggests that any differences in map score between boys and girls may have more to do with the different activities boys and girls take part in, rather than simply being an intrinsic difference.

The next most important factor is the school that the children attend, with quite a large advantage being conferred by attending Burleigh Primary School. It is likely that it is the area around the school, the subject of the child's area map, that is responsible for the difference. Although alternative explanations, such as differences in teaching in the two schools, can not be discounted.

There does seem to be a positive benefit from time spent away from the home, time spent in structured and unstructured (play) activities both make increase map score, whilst time spent at home decreases map score.

10.7.1 Car travel and map score

Although the B values in the above table might at first suggest that duration has a negligible effect on the level of DI, it should be remembered that these figures are in minutes, so an hour spent in the car at the weekend has the effect of decreasing the map score by 3.6. It is interesting that car journeys have a positive impact on map score when they are at the weekend, this might be due to the different nature of car journeys at the weekend.

During the week a large proportion of the travel recorded in the diaries represents school travel, durations recorded in the CATS diary reveal that school travel makes up 56% of journey durations at Flamstead End Primary School and 65% at Burleigh Primary School. At the weekend there is no school travel. Children spend more time travelling at the weekend, on average 15.8 minutes are spent during the week and 25.5 minutes are spent travelling at the weekend.

Even though the positive contribution of car travel at the weekend is less than the negative contribution during the week, the fact that children do more of it, may mean that they cancel each other out.

10.8 Chapter summary

This chapter begins to consider the results of the bidimensional regression, considering the distortion present in the maps, and asking whether there is a relationship with travel mode. Sketch map distortion has been combined with the sketch map detail to produce a weighted measure. Weighting the scores according to the number of identifiable elements represented in the map has been done to give greater weight to more complete maps. This weighted measure also has the advantage of allowing both factors to be considered at the same time.

There appears to be a link between the amount of time a child spends as a car passenger and the distortion present in their map. The remainder of the chapter takes this analysis further by considering a model of map accuracy that includes the child's sex, their school year, and their dominant travel mode.

The ANOVA reveals significant differences in map score for the children who spend more time walking than in the car. There was no significant difference in map score between boys and girls, once again the school that the children attend emerges as an important influence on map score. It is possible that it is the area that the school is located in, rather than anything about the school itself, which is affecting the children's maps scores. Although it is possible that it is other differences between the schools, such as socioeconomic circumstances of the families or the teaching in the school, that are responsible for these differences

The regression equation considered the durations for all of the activity types recorded in the children's CATS diaries. School or area is once again highlighted as an important influence, with higher map scores for those in Burleigh Primary School. There is an interesting result for car travel, which seems to make a positive contribution to map score at weekends and negative contributions during the week. Overall the contribution of car travel in this model is unclear.

There does seem to be a positive benefit from being away from the home, structured and unstructured (play) activities both make a positive contribution while being at home make a negative contribution.

11 Discussion

The idea for this research arose from an interest in the psychological impacts of the journey to school, particularly the mode chosen for the journey. There has been much written on the physical activity, health and environmental issues associated with increased car use. Health impacts include the increased early mortality and morbidity associated with childhood, and adult, obesity. Active travel has been suggested as something that can be built into children's everyday lives to help defuse the obesity time-bomb. There have been studies that link active travel with the reduction of negative psychological conditions, such as anxiety and depression, but there is less work that deals with the cognition of large-scale spaces and the development of wayfinding skills in children as a result of day-to-day travel.

There is wide recognition that children have become more dependent on both motorised transport and parental accompaniment when travelling. If children are to become less car dependent then there is a requirement for good, independent travel planning skills. The concept of the cognitive map was chosen as the focus for research because spatial representations are closely linked with the process of wayfinding, and this process is a vital underpinning for children's independent activities, including travel.

If it is children's experience of their local environments that is crucial in building up good representations, and thereby good travel planning skills, then it should be expected that the ways in which they interact with the environment, and the environment itself will be important factors in determining children's spatial skills.

11.1 Addressing the aims of the research

In the introduction a number of aims for the research were set out (see Section 1.1). The main aim of this research was to investigate the possibility that a link exists between children's interaction with the local environment and their cognitive representations of the environment. This was addressed by the regression analyses in Chapter 7 and Chapter 10. The analysis in Chapter 7 used factors derived from a factor analysis of the child questionnaire. The questionnaire factors were included in a regression analysis investigating their contribution to map score (see Section 7.5). The analysis in Chapter 10 investigated the influence on map score from time spent in different activities, as measured by the children's diaries (see Section 10.10).

Further aims of the thesis were related to the need to develop research instruments that could be used to build up a picture of the children’s lives, their behaviours and travel patterns, and also to investigate the quality of the children’s mental representations of their local environments.

The development of measures of spatial knowledge, and the attempt to develop a GPS based activity measure are covered in Chapter 5. The questionnaire, and the factors that can be derived from it are covered in Chapter 7. Another instrument that produces a measure of children’s travel and behaviour is the CATS diary. The duration results from this travel and activity diary are used in Chapter 10 to split children into those whose main mode of travel is walking, and those whose main mode is the car. The map scores for the two groups of children were then compared (see Sections 10.4 and 10.5). The durations of the other activities in the diary were used in a regression equation with weighted map score as the dependent variable (see Sections 10.7).

Chapters 5 and 6 describe the development of the sketch mapping task and the methods for producing measures of children’s cognitive maps of the local area, addressing the objective to develope a methodology for recording and analysing children’s representations of the local environment. Chapter 8, 9 and 10 all make use of the results derived from the sketch mapping tasks, including measures of representational style, detail and accuracy.

The research focused on children’s sketch maps and investigated different methods of analysis; including style, detail and accuracy. The measurement of accuracy, obtained using bidimensional regression, has been combined with a measure of detail to provide an overall map score.

Results from a range of analyses, correlation, ANOVA and regression, suggest that map score is influenced by age, mode of travel, some activities and the school that the child attends.

11.2 The importance of examining travel mode

Travel mode and accompaniment were seen as important mediators of environmental experience. When a child is accompanied, particularly when accompanied by an adult, there is less, sometimes no, requirement to monitor current location and plan routes. There is also a distinction between the intensity and focus of attention required by a child when walking and when travelling as a passenger. When travelling as a passenger, it can be argued that there is no requirement for the child to focus on the actual journey, as their degree of attention will have no influence on the outcome of the journey, particularly when the child is travelling as a passenger in a car.

A similar argument can be made for public transport, with the modification that some monitoring of the progress of the journey may be required, assuming that the child is on the right bus, coach, train, etc. in the first place, something that may require some attention to the outside world. The reason for saying 'may' in the preceding sentence is that if a child is being accompanied, the person with them may take responsibility for these decisions, particularly if they are being accompanied by an adult.

11.3 Developing a measure of spatial awareness

Theories of cognitive mapping highlight the importance of experience and attention in learning about an environment. Repeated experience in an environment can be seen as the mechanism that allows knowledge about the environment to progress from simple landmark, to full survey knowledge. Because of the importance of the children's environment in the investigation, it was useful to base a measure of spatial ability on it, in an attempt to measure environmental competence rather than small-scale spatial skills.

One of the main measures employed in this research was distortion index (DI), also recast as a map score, which provided a relatively objective metric to judge the quality of area sketch maps.

There is potential to use the methodology for measuring the accuracy and detail in children's cognitive spatial representations in other settings. There are a number of questions within the field of psychology, transport studies and children's geographies that would be amenable to investigation using the methodology developed in this thesis. Previous literature indicates that cognitive mapping was seen as a promising approach, but one that has been underutilised in recent years. This work has demonstrated a methodology for analysis that could be adapted for research in other areas.

11.4 Unsurprising differences as children get older

It was reassuring to see that all the measures of sketch map quality showed an age progression, whether it was the proportion of the most cartographically competent maps, or the level of distortion present in the representation. The skills involved in building up cognitive representations improve with age. Seeing no, or negative, association, would suggest that there were serious problems with the measure.

11.5 Possibly surprising lack of difference between the sexes

There was very little evidence of difference between boys and girls on any of the measures, which is surprising if small-scale spatial skills are closely associated with large-scale spatial skills. One difference that was observed was that girls tended to record more detail in their maps than boys.

This finding supports the disassociation of small-scale and large-scale spatial skills.

11.6 Surprising differences between the schools

The two schools were chosen initially with an expectation that they would provide one large sample that could be analysed for differences in cognitive map quality arising from differences in travel mode. Once analysis began on the data, however, it was clear that the children at the two schools were at different levels in terms of map accuracy and representational style.

In almost all cases, Burleigh Primary School has an advantage over Flamstead End Primary School. Plotting the landmarks (Figure 11-1) that the children included in the maps revealed a town that is split in two by a busy road. The influence of heavy traffic, even in a world where children can be ferried around as car passengers, is striking. The relative isolation of the two groups is probably what leads to the differences that are seen in the outcome measures, rather than a marked difference between the two schools themselves.

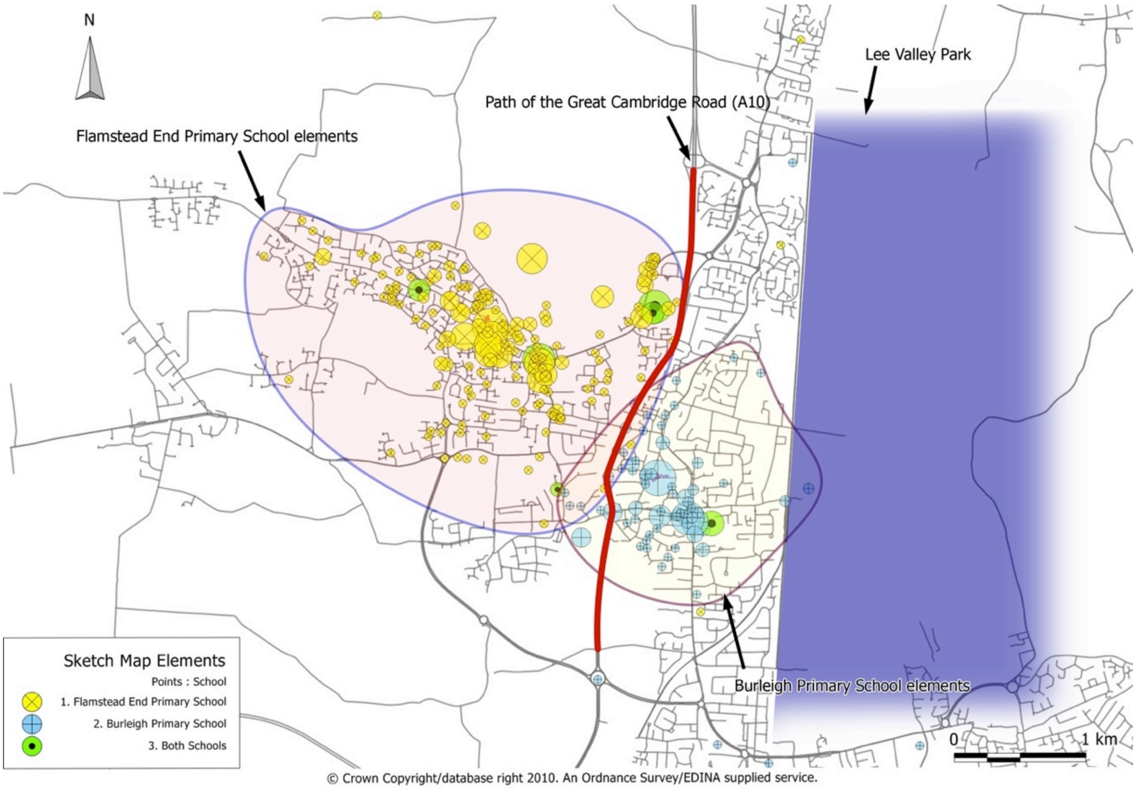


Figure 11-1: Distribution of elements for the two Cheshunt schools

It seems likely that it is the relative density of Cheshunt Central Ward (Burleigh Primary School) and the more homogenous nature of building types in Flamstead End Ward (Flamstead End Primary School) that lead to this difference. Examining the children's maps and photographs of the area reveals that there is simply more colourful variety, including shop fronts, fire stations and giant fountains, in and around the town centre.

The differences in sketch map quality are really quite large, often around the same gain as can be expected from advancing a school year. However, it is not clear if this represents a transferable advantage.

An alternative possibility is that the advantage seen in the Burleigh Primary School children is due to their higher levels of independent mobility, revealed by the factor analysis of the questionnaire. Independent mobility might be the link between area and cognitive map quality, in this case it is more likely that the differential in sketch map quality represents a transferable skill.

11.7 Cognitive maps more distorted for car users

There are two findings that suggest cognitive map distortion is higher for car users. The first is the simple correlation between DI (Distortion Index) and time spent travelling by car. The second is the result of the ANOVA tests that test dominant mode in models that include school, school year and sex. The correlation results are weak but do suggest that there is some support for the hypothesis that children's car use has an impact on their spatial skills.

The results of the regression modelling, reveal the contribution of car travel to distortion is relatively small, but significant. However, it acts in different directions depending on whether the journeys are during the week, or at the weekend, so no clear picture emerges from this analysis.

There is the possibility that encouraging active travel modes in children could provide a boost to their wayfinding skills. It is likely that it is the parent's assessment of their children's ability to get around safely that determines what licences children are granted for their independent behaviours. If so, initiatives that encourage walking or cycling to school, could have the knock-on effect of increasing children's independent travel to other locations and expanding their geographical range.

11.8 Map scores and children's activities

The regression model that considers the contribution of children's activities, as recorded in the CAPABLE CATS (Children's Activities Perceptions and Behaviours in the Local Environment; Children's Activity and Travel Survey) diary reveals a very low value for adjusted R^2. This shows that the factors that have been considered in this thesis are only part of the picture. This is perhaps not surprising, as variation in the quality of cognitive maps, and the ability to recall the information that they contain, is influenced by a large variety of factors, only some of which are under examination here. The children's ability to draw and possibly their intelligence will play a role. Finding the other factors that determine children's mapping skills could be a topic for useful future work.

The regression model does reveal an advantage amongst children who spend time out of the house, particularly if they spend that time playing outside (unstructured activities) or in structured activities, such as sports clubs.

11.9 Further research

There are a number of areas that would merit further attention, some of them would require reanalysis of the existing data and others would be new pieces of work. Reanalysis would include looking at the way that children represent networks in their maps. Another possibility would be to include the physical activity monitoring data, gathered for the same sample of children as part of the CAPABLE study, to examine possible links.

One very interesting piece of work would be to rerun the GPS monitoring study to compare experience and subsequent recall of routes. This study would require either better equipment, or some experimental intervention in planning routes for the participants to follow- routes that worked with the limitations of the GPS.

Yet another interesting study would be to run a similar sketch mapping study with older children or adults. There is a strong age gradient in the results, and it is not clear if the differences caused by environment or travel mode would even out as children grew up.

In any future study that involved sketch mapping, it would be interesting to spend more time looking at the process of sketch mapping rather than just the finished artefact. However, this would probably necessitate working with smaller groups.

11.10 Concluding thoughts

The strength of this work, from the point of view of its contribution to the psychological literature, is that it deals with children in their own environments. Even though the research made use of paper and pencil instruments to investigate children's environmental knowledge, the tasks dealt with the child's immediate local environment, and not abstract small-scale spatial problems, which are more common in cognitive psychology experiments.

In terms of a contribution to human geography, the research addresses children's everyday activity and their perception of their local environments, questions which have been studied in both environmental psychology and children's geography. Current approaches in children's geography have an emphasis on identity formation and power relationships, the methodologies for assessing children's cognitive maps of areas add another dimension to this picture of children and their relationship with spaces.

Another point worth noting is that the sketch mapping tasks were also interesting exercises which engaged the children.

Sketch mapping provides a very rich, but problematic, dataset. The freedom to include as many, or as few elements as the child wished, or could remember was an important advantage to this methodology, as it ensures a flexible instrument. There are certain difficulties in analysis, but they are eased somewhat by modern GIS packages and web based mapping resources.

This thesis has demonstrated that maps sketched by children can be successfully used to measure their spatial skills. There are almost endless combinations of map related measures and measures of behaviour from the diaries and questionnaires. The combinations presented in this thesis aimed to highlight the importance of a child's travel mode, which is consistently present as a significant predictor of sketch map, and possibly cognitive map, quality.

Appendix 1: CAPABLE project letters

Appendix 1a: Recruitment letter sent to schools who had expressed an interest in taking part in further work

Centre for Transport Studies
University College London
Gower Street
London
WC1E 6BT

Insert Date

Dear Sir/Madam,

Volunteers needed for a new University College London research project

As you may recall you took part in a questionnaire survey about the walking bus initiative in Hertfordshire. At that time you indicated that your school might be interested in taking part in future research.

The walking bus survey was part of a larger project, *Reducing children's car use: the health and potential car dependency impacts.* Another component of that project was CATS (*Children's Activity and Travel Study*) which measured children's physical activity and travel patterns. The findings from CATS have contributed to the ongoing debate about children's physical activity; study findings have been widely disseminated, appearing in the national press and magazine articles as well as being presented at national and international conferences.

Our current project, CAPABLE (*Children's Activities Perceptions and Behaviours in the Local Environment*), aims to build on the CATS findings. In addition to measuring the physical activity and travel patterns of children, CAPABLE aims to investigate children's interaction with, and their perceptions of, the local environment.

We would like to work with at least one group of twenty children at your school. The children would be asked to wear monitors that measure their physical activity and location over six days, two of them at the weekend. Apart from setting up and issuing the monitors, and collecting them at the end of the period the monitors will not interfere with the children's activities during the school day. In addition participating children would have their heights, weights and body fat levels measured, they would also complete some classroom based exercises. These activities obviously have a greater impact on school time. In total we would require time to run two morning sessions plus some briefer follow up visits.

There is, however, an opportunity to integrate this work into the curriculum; the work raises ideas that relate to transport, geography, psychology and biology: How and where people travel, perceptions of the local environment, cognitive skills, physical activity patterns and body composition. Involvement in the project also provides an opportunity demonstrate how these can be measured. We are quite happy to supply datasets from our monitoring for teaching purposes. Any data supplied will be randomised and anonymised so that individuals cannot be identified.

If you are interested in this project and would like further information please complete the tear-off slip and return it in the Freepost envelope provided.

Yours Faithfully

Professor Roger Mackett

020 7679 1554
rlm@transport.ucl.ac.uk

CAPABLE

School Name

Headteacher's name: ________________________________

Please send me further details about the CAPABLE research project

Appendix 1b: Parental consent letter for the CAPABLE project

The consent letter for the CAPABLE study is shown here, the letter for the Children's Car Use study was not different in any significant way.

Centre for Transport Studies
University College London
Chadwick Building
Gower Street
London
WC1E 6BT

UCL

CAPABLE: Children's Activities, Perceptions and Behaviour in the Local Environment

January 2006

Dear Parent,

Burleigh Primary School is involved in fieldwork for the CAPABLE research project investigating how children use and perceive their local environments. The project is based at University College London; more details about the project can be found on our website at http://www.casa.ucl.ac.uk/capableproject/. The current stage of the project involves using GPS (global positioning system) and RT3 physical activity monitors to build up a detailed picture of children's travel and their associated physical activity.

We are looking for pupils who are interested in being involved in this study: the volunteers will be asked to wear the two monitors for a period of 5 days, from Wednesday afternoon through to Monday morning; both units are worn from the getting up in the morning until going to bed. The RT3 (the physical activity monitor) is the size of a pager and worn in a belt around the waist. It calculates physical activity based on how much the wearer moves about. The GPS unit is a similar size; it is worn on the wrist and records the wearer's location. The RT3 unit does not require any intervention, but the GPS unit will need to be recharged at the end of each day. As well as wearing the monitors, we would like each child to complete a travel and activity diary. We would appreciate your help in keeping the diaries up to date and charging the GPS units overnight. The children will be given guidance notes covering all the aspects of participating in the study.

The calculations for physical activity level require the child's height and weight to be input into the RT3 unit. As part of the study we shall be measuring the height, weight and body-fat level of each participant.

The units can be worn without getting in the way of a child's everyday activity and they are rugged enough to survive some rough treatment. The units are not waterproof, so they should be removed before swimming or taking part in any other activity where they might get wet. We are aware that this kind of interesting electronic equipment may attract unwanted attention, and if a situation arises where someone tries to take either unit, then we would rather lose a piece of equipment than run the risk of anything happening to a child.

We can include around 20 children each week and we are planning to run enough sessions to include all the children who wish to take part. If you would like your child to take part in the study, please complete the consent form below and return it to the school as soon as possible.

Yours faithfully

R L Mackett

Professor Roger Mackett

For further information please contact James Paskins
Telephone: 020 7679 7872
Email: james@transport.ucl.ac.uk

Tear here

Consent from parent or guardian for participation in the CAPABLE children's location and physical activity monitoring exercise

I give permission for my child ________________________________in Class ________to wear a motion sensor and a location sensor for the five days of this exercise and to take part in the weighing and measuring exercise

I understand my child can withdraw from this study at any time.

Name ________________________________

Signed ______________________________ Date _______________

Please tear off the completed form and give it to your child to return to school.

Appendix 2: Example pages from the CATS travel and Activity diary

Weekday Example

Before School

Location		What did you do there?
I began the day at Home ☑ Somewhere else ☐ Please say where	I woke up at 7:00 I put my sensors on at 7:15	I had my breakfast and got ready for school. I left at 8:35
Then I went to	I got there at : I travelled by I travelled: • by myself ☐ • with an adult ☐ • with other children ☐	I left at :

I arrived at school at 8:45 I travelled by Car
I travelled: by myself ☐ with an adult ☑ with other children ☑

At School

What did you do	*Please say what the start and end times were*	Start	End
• Before lessons started?		:	:
• At morning break?	Ran around	10:15	10:30
• At lunch break?	Sat around and talked with friends	12:15	1:15
• At afternoon break?		:	:
• During PE/Games?	Catching and throwing	1:30	2:30

I left school at 3:20

After School

After school I went My friend's house	I got there at 3:30 I travelled by Car I travelled: • by myself ☐ • with an adult ☑ • with other children ☑	Played hide and seek Had tea I left at 5:30
Then I went to	I got there at : I travelled by I travelled: • by myself ☐ • with an adult ☐ • with other children ☐	I left at :

What time did you eat your evening meal? 5:00

Evening

Then I went to Brownies	I got there at 5:50 I travelled by Car I travelled: • by myself ☐ • with an adult ☑ • with other children ☐	Did drawing Played Games I left at 7:15
Then I went to Home	I got there at 7:30 I travelled by Walking I travelled: • by myself ☑ • with an adult ☐ • with other children ☐	Had dinner Had a bath Did my homework Went to bed I left at :

I ended the day at Home ☑ Somewhere else ☐ Please say where	I went to bed at 9: 30 I took my sensors off at 9:00

Weekend Example

	Location		What did you do there?
Morning	I began the day at Home ☑ Somewhere else ☐ Please say where	I woke up at 6:30 I put my sensors on at 7:00	*Had breakfast* *Got ready to go out* I left at 8:20
	Then I went to *Ikea Thurrock*	I got there at 9:30 I travelled by *Car* I travelled: • by myself ☐ • with an adult ☑ • with other children ☐	*Walked round the shop and went to the café for lunch* I left at 12:00
	Then I went to	I got there at : I travelled by I travelled: • by myself ☐ • with an adult ☐ • with other children ☐	I left at :
What time did you eat lunch?			11:45
Afternoon	Then I went to *Lakeside shopping centre Thurrock*	I got there at 12:05 I travelled by *Car* I travelled: • by myself ☐ • with an adult ☑ • with other children ☐	*Walked round the shops* I left at 3:30
	Then I went to *Home*	I got there at 4:30 I travelled by *Car* I travelled: • by myself ☐ • with an adult ☑ • with other children ☐	*Played a computer game* *Watched TV* I left at :
What time did you eat your evening meal?			6:00
Evening	Then I went to *Still at home !*	~~I got there at :~~ ~~I travelled by~~ ~~I travelled: • by myself ☐~~ ~~• with an adult ☐~~ ~~• with other children ☐~~	*Watched some more TV* I left at :
	Then I went to	I got there at : I travelled by I travelled: • by myself ☐ • with an adult ☐ • with other children ☐	I left at :
	I ended the day at Home ☑ Somewhere else ☐ Please say where	I went to bed at 9:30 I took my sensors off at 9:00	

Appendix 3: Equipment used for the Children's Activity and Travel Study (CATS)

Two different kinds of electronic sensor were worn by the participants in the Children's Activity and Travel Study, part of the EPSRC funded CAPABLE project: A physical activity monitor and a GPS monitor.

Choosing a physical activity monitor

Physical activity was recorded using the RT3 Tri-axial research tracker and the Garmin Foretrex 201, both of which are described in more detail below. Choosing the right piece of equipment for each monitoring task (position and physical activity) involved balancing a number of factors, which included: battery life, measurement options, data logging capacity, ease of use, battery life, size, weight and resilience.

The RT3, shown below in Figure A3-1, offered 3-dimensional physical activity monitoring in a small light package. The RT3 unit is a pager-sized accelerometer capable of recording displacement in along all three axes of movement. A dock unit was supplied to allow the RT3 to communicate with the supplied software; the software allowed the data points to be transferred to a computer and stored in a simple text format, compatible with standard spreadsheet and database packages.

Figure A3-1: The RT3 physical activity monitor. The RT3 unit can be seen on the left, the picture on the right shows the unit in a neoprene belt and holster.

The software was also used for the initialisation process. Each time the unit was used with a new participant, the unit set its internal clock and calendar and was personalised with the name, age, height, weight and sex of the participant. As well as providing a unique identifier for the participants data file, the supplied information was used to calculate a conversion factor, allowing the calculation of the participant's resting metabolic rate and allowed each datapoint in the file to be converted from Activity Counts into Activity Calories (an estimate of the energy expended for the time period covered by the datapoint).

The RT3 major advantage was that once it had been setup, the unit required no intervention from the user. As long as the child was wearing the unit it would continue record his or her movement. The recording capacity, the number of individual data points that could be captured, and the amount of time the device could be powered without changing the battery, were both well in excess of the requirements of the study. The unit could have been used for continuous physical activity monitoring for 21 days.

There were, however, some disadvantages to the RT3 unit. Disadvantages included a lack of water proofing, a poorly designed docking system that caused problems initialising and reading data from the unit and the fact that if the battery is removed from the unit it loses all data recorded up to that point, and returns to an uninitialized state. Detailed guidance notes, perseverance and taping the battery compartment shut, solved the majority of the problems that were encountered.

Choosing a GPS unit

The Global Positioning System (GPS) was originally designed in the 1970s for the United States Department of Defense (US DOD). The intention was to provide a portable system that could provide highly accurate and near instantaneous information about longitude, latitude and altitude anywhere on the globe. Originally NAVSTAR, the US DOD name for the system, was intended exclusively for use by the United States military, now, however, the system has a worldwide civilian user base

The choice of GPS unit was much more problematic than the choice of activity monitor. GPS systems rely on timing signals sent from a constellation of satellites that orbit the earth at an altitude of about 12,000 miles. Each of the NAVSTAR satellites, which make up the constellation of GPS satellite, transmits a very weak (50 Watt) radio signal

(Kaplan and Hegarty 2006). By the time the signal gets to ground level it can be very faint.

Because the signal travels so far, and is so faint, there is a lot of room for the introduction of error. Atmospheric conditions, the GPS units aerial and the amplification and decoding of the signal, not to mention the immediate surrounding of the user can all introduce error, or delay into the GPS unit's output.

Because of these, and other factors, there is a wide range of GPS units, differentiated in the level of accuracy to which they can record position information. More precise units are generally more expensive, more power hungry, larger and heavier.

So while it was possible to purchase accurate data logging GPS systems with long battery lives, the units considered all turned out to be too large and cumbersome for use by children. The size and weight of the units considered was such that it was likely that the units would either have a major impact on the child's behaviour or simply be left behind when the child left the house.

In some respects the ideal the GPS unit would have been very similar to the RT3 unit, small and light with a long battery life, at least as long as the 4-5 days required to capture the participant's movements during the study. Ideally it would also feature a high capacity data logger. Both these factors would facilitate a wear and forget design, allowing the unit to be given to the child in the same way that the RT3 unit was initialised and given to the child, with the only important instruction being to wear the unit.

Other desirable factors would include being quick to achieve a first fix on position, GPS units don't generally receive any signal when indoors, so the more quickly a fix can be achieved when going outdoors the more likely it is that children's outdoor activity will be recorded. In addition the ideal unit would not only be accurate, but store information about the accuracy of each of its position fixes.

An additional and important consideration for this equipment was that it wouldn't make our participants into targets for crime. The unit should not be anything too conspicuous, or at least it shouldn't look like expensive equipment.

The GeoStats Geologger, shown below in figure A3-2, was adapted from a very accurate system for monitoring vehicle position. The unit fulfils many of the criteria for an ideal GPS unit. It has the desired long battery life and large data capacity. It also has very fast time to the first fix, records data at a very high frequency and records how many satellites it was tracking at the time (which gives an idea of the accuracy of the position information.

Figure A3-2: GeoStats Geologger, a nearly ideal wearable GPS system

Unfortunately the GeoStats Geologger was too large and cumbersome to be worn by the children in the study. It was felt that it was one of the systems that was so large it would affect the behaviour of the child who was wearing it, or simply not be worn at all.

The decision about a GPS monitoring system came down to a compromise between size and weight and the capabilities of the unit. The unit chosen, shown below in Figure A3-3, was small and light, but sacrificed some of the ease of use of the other units considered. The fact that the unit was small and light enough to be worn inconspicuously by the child was felt to more than make up for the fact that it fell short of the ideal characteristics for the GPS unit.

The shortcomings included, a relatively short (one day) battery life, often taking a long time to gain an initial fix and the fact it did not store any information about the accuracy of the position information it gathered.

Figure A3-3: The GPS unit chosen for the research, the wristworn Garmin Foretrex 201

Appendix 4: Sketch map task instructions

The two sheets in this appendix give the spoken instructions for he children taking part in the sketch mapping tasks. The investigator read out the relevant script after the worksheets for the current task had been handed out. Words in italics in the area map script indicate actions for the investigator, for instance, pointing to North in the classroom.

Route map instructions

Write your name, the name of your school, the class you are in and today's date in the boxes at the top of your sheet.

Write down the way that you travelled to school this morning in the box provided.

You will have 15 minutes to draw a map of the route you followed to get to school this morning.

Try to include as many landmarks and places as you can remember, these will make your map easier to follow.

Think about all of the things that you passed on your journey to school this morning. These could be:

traffic lights,

crossings,

houses,

blocks of flats,

other schools,

shops,

parks,

playgrounds,

statues,

and anything else you pass.

Try to remember as many names for these places as you can and write them on your map.

You should also include as many roads, junctions and roundabouts as you can. If you can remember their names, write these down on your maps as well.

Remember:

Try and draw a map that would allow someone to follow the route that you took.

Write "My House" next to your house and "My School" next to your school.

Think about how large the map has to be before you start drawing it. You have to be able to fit your home and the school on the map.

Area map instructions

Write your name, the name of your school, the class you are in and today's date in the boxes at the top of your sheet.

This sheet has an aerial view of your school in the middle.

Point to school on sheet

This is the front gate

Point to front gate on the sheet

This is your classroom

Point to the part of the school they are currently sitting in

Up on this sheet is North, in this direction

Point to North in the classroom

You will have 15 minutes to draw a map of area around your school.

Try to include as many landmarks and places as you can remember near your school.

Think about all of the things that are near your school. These could be:

traffic lights,

crossings,

houses,

blocks of flats,

other schools,

shops,

parks,

playgrounds,

statues,

and anything else nearby.

Try to remember as many names for these places as you can and write them on your map.

You should also include as many roads, junctions and roundabouts as you can. If you can remember their names, write these down on your maps as well.

Appendix 5: Worksheet for route map

About your journey to school this morning

Use the space below to draw a map of the route you followed to get to school this morning. Include as many road names as you can remember. You can also include any places that will make the map easier to follow; these might be shops, parks, roundabouts or traffic lights.

Thank you for taking part.

Appendix 6: Worksheet for area map

About the area around your school

Use the space below to draw a map of the area around your school. Include as many places and roads as you can remember.

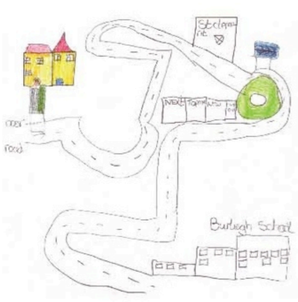
Thank you for taking part.

Appendix 7: Pictorial sketch maps

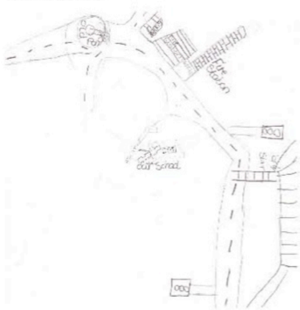
This appendix contains all the sketch maps for children whose area sketch maps were been classified as having been drawn in a "Pictorial" style.

Reference Number
BP4-004
School
Burleigh Primary School
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map

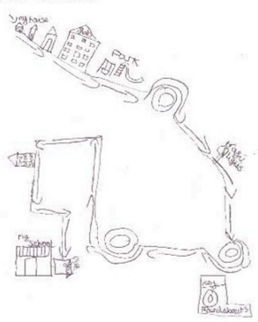


Area - Sketch Map

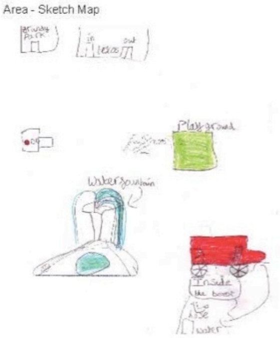


Reference Number
BP4-018
School
Burleigh Primary School
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map



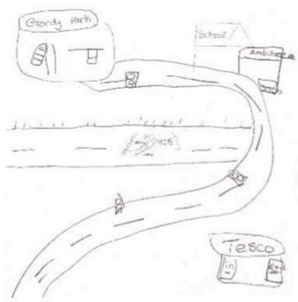
Area - Sketch Map



Reference Number
BP4-013
School
Burleigh Primary School
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

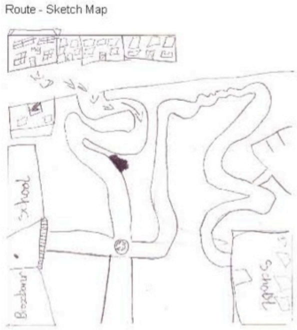
Route - Sketch Map

Area - Sketch Map

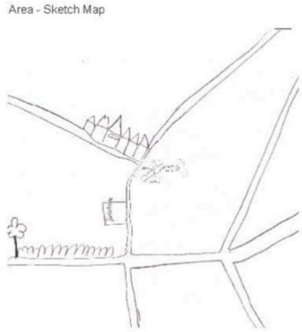


Reference Number
BP4-006
School
Burleigh Primary School
School year
4
Route - Cartographic Competence
Plan-Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-009

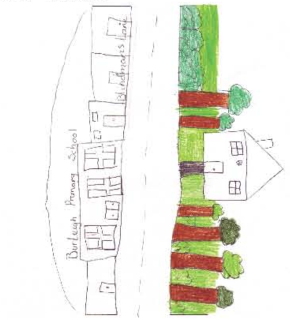
School
Burleigh Primary School

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number
BP4-014

School
Burleigh Primary School

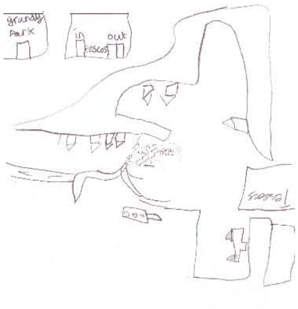
School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number
BP4-012

School
Burleigh Primary School

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

Area - Sketch Map

Reference Number
BP4-011

School
Burleigh Primary School

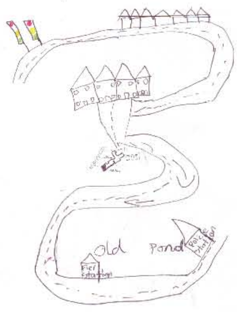
School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number

BP4-021

School

Burleigh Primary School

School year

4

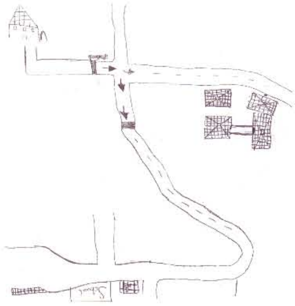
Route - Cartographic Competence

Plan–Pictorial

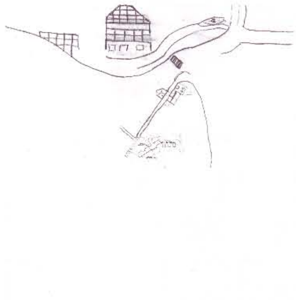
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-025

School

Burleigh Primary School

School year

4

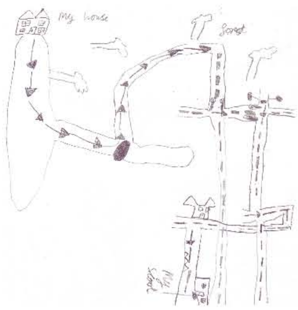
Route - Cartographic Competence

Plan–Pictorial

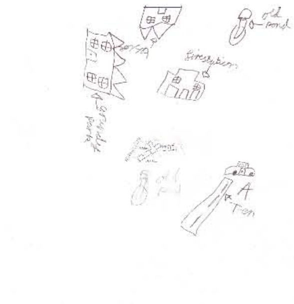
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-005

School

Burleigh Primary School

School year

4

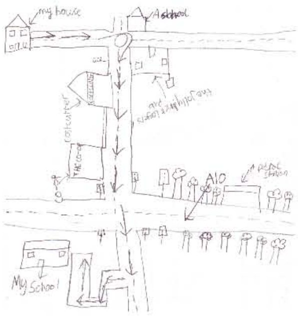
Route - Cartographic Competence

Plan–Pictorial

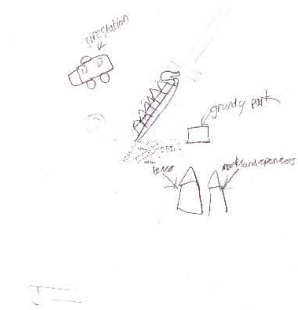
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-024

School

Burleigh Primary School

School year

4

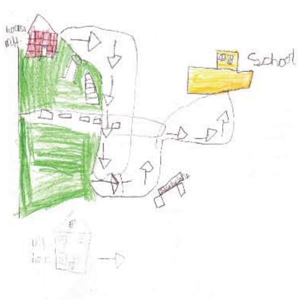
Route - Cartographic Competence

Pictorial

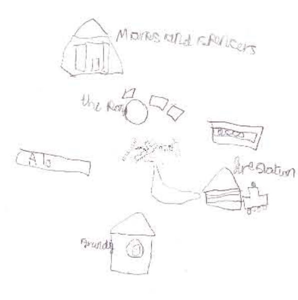
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-002

School

Burleigh Primary School

School year

4

Route - Cartographic Competence

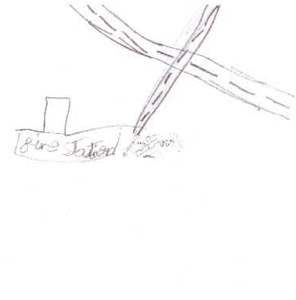
Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number

BP4-003

School

Burleigh Primary School

School year

4

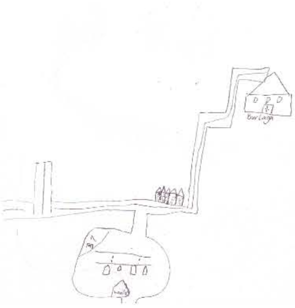
Route - Cartographic Competence

Plan-Pictorial

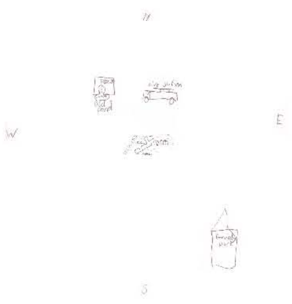
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-028

School

Burleigh Primary School

School year

4

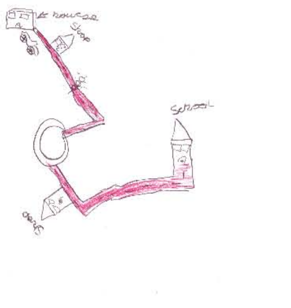
Route - Cartographic Competence

Pictorial

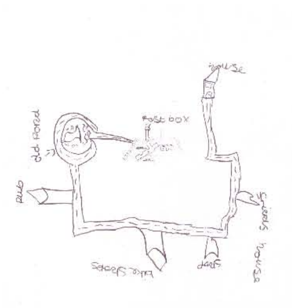
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-029

School

Burleigh Primary School

School year

4

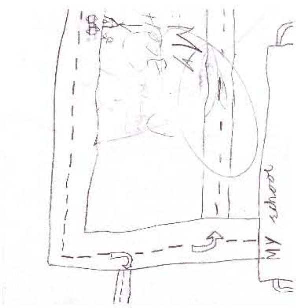
Route - Cartographic Competence

Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number

BP4-039

School

Burleigh Primary School

School year

4

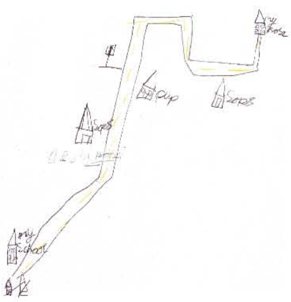
Route - Cartographic Competence

Pictorial

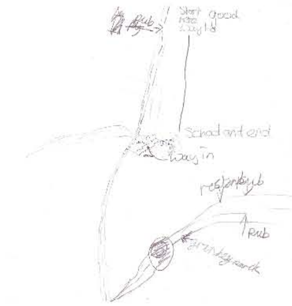
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-049

School

Burleigh Primary School

School year

4

Route - Cartographic Competence

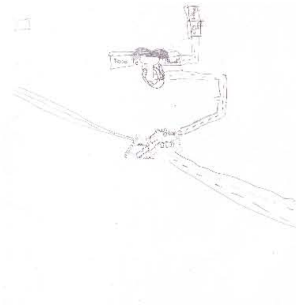
Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number

BP4-048

School

Burleigh Primary School

School year

4

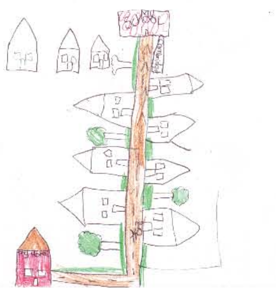
Route - Cartographic Competence

Pictorial

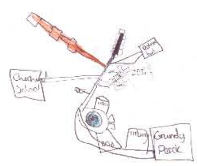
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-031

School

Burleigh Primary School

School year

4

Route - Cartographic Competence

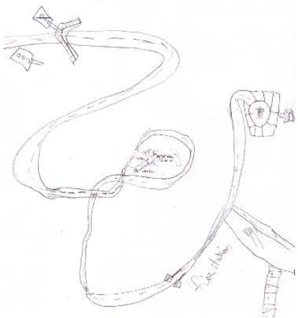
Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number
BP4-042

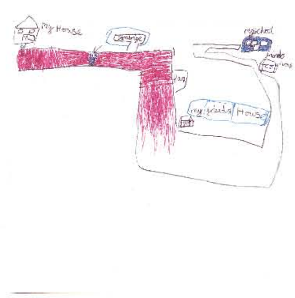
School
Burleigh Primary School

School year
4

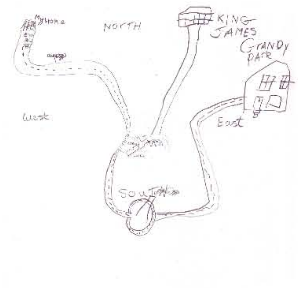
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-050

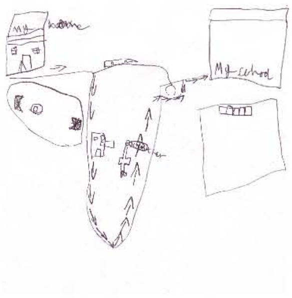
School
Burleigh Primary School

School year
4

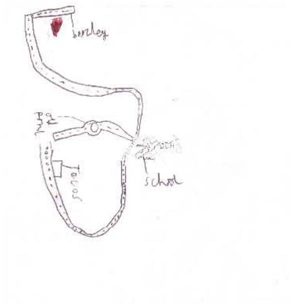
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-038

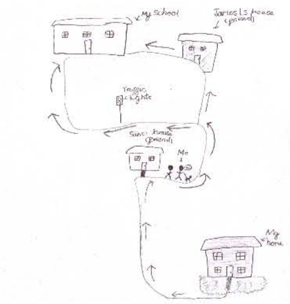
School
Burleigh Primary School

School year
4

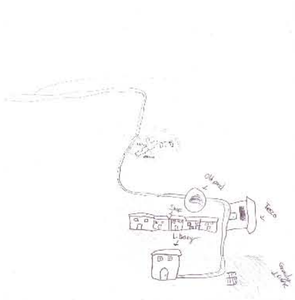
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-053

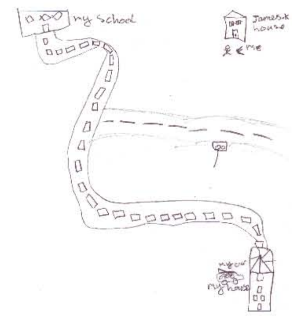
School
Burleigh Primary School

School year
4

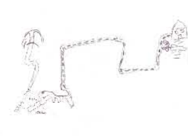
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-055

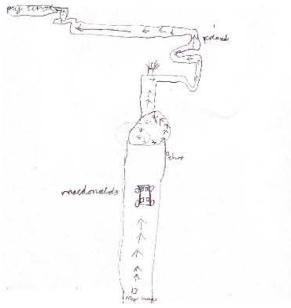
School
Burleigh Primary School

School year
4

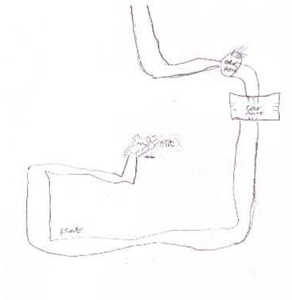
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-045

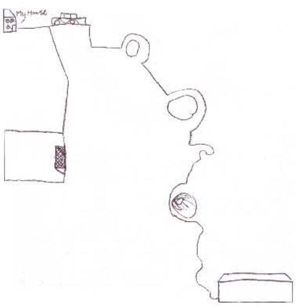
School
Burleigh Primary School

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number
BP4-032

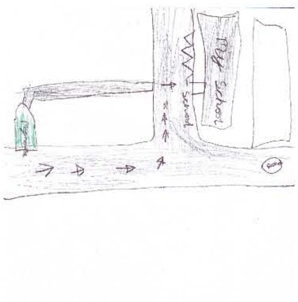
School
Burleigh Primary School

School year
4

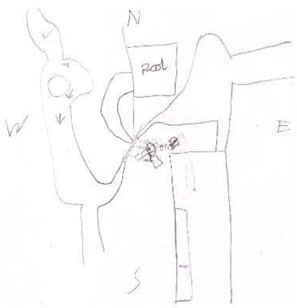
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-052

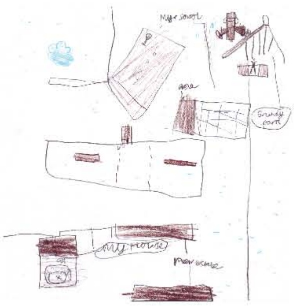
School
Burleigh Primary School

School year
4

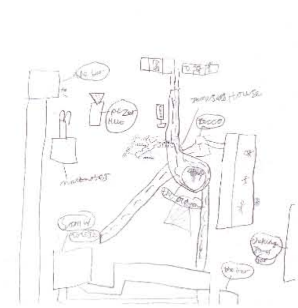
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

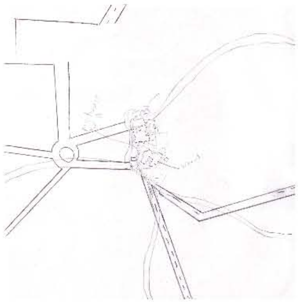


Area - Sketch Map

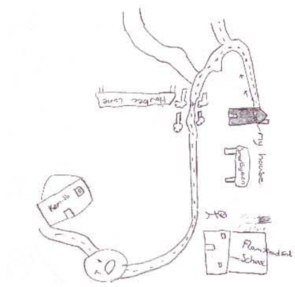


Reference Number
FE4-028
School
Flamstead End Primary Sc...
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map

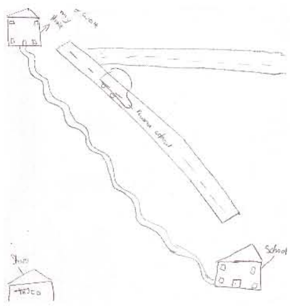

Area - Sketch Map


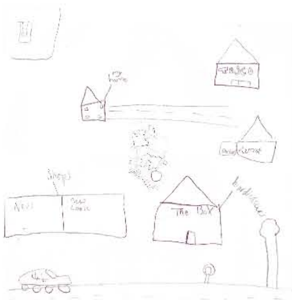
Reference Number
FE4-010
School
Flamstead End Primary Sc...
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map


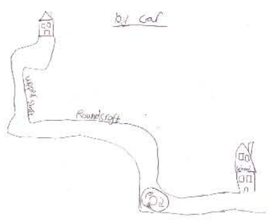
Area - Sketch Map

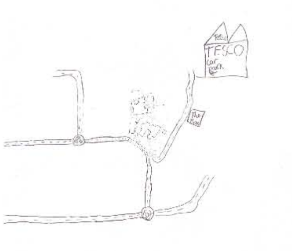

Reference Number
FE4-036
School
Flamstead End Primary Sc...
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map


Area - Sketch Map


Reference Number
FE4-003
School
Flamstead End Primary Sc...
School year
4
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map


Area - Sketch Map


Reference Number
FE4-018

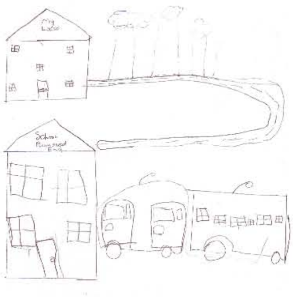
School
Flamstead End Primary Sc...

School year
4

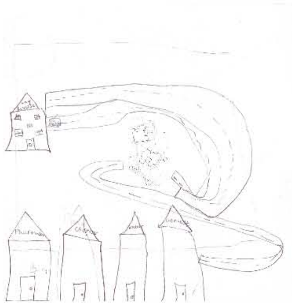
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-035

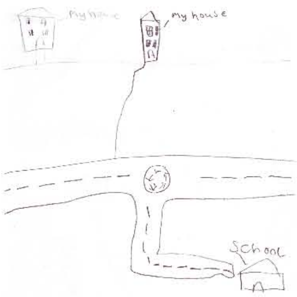
School
Flamstead End Primary Sc...

School year
4

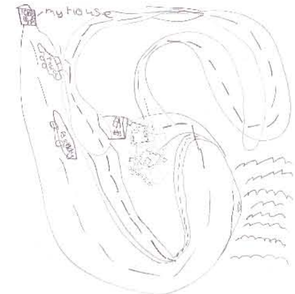
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-033

School
Flamstead End Primary Sc...

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

Area - Sketch Map

Reference Number
FE4-032

School
Flamstead End Primary Sc...

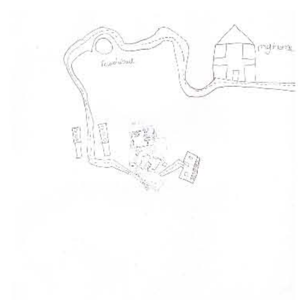
School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number

FE4-014

School

Flamstead End Primary Sc...

School year

4

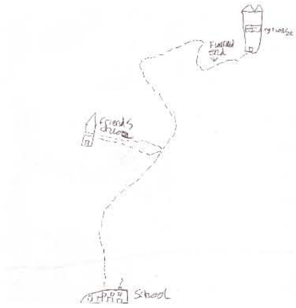
Route - Cartographic Competence

Plan–Pictorial

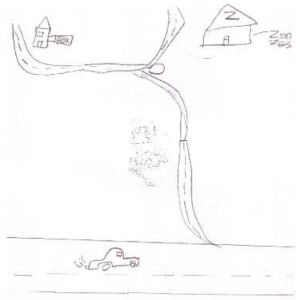
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-012

School

Flamstead End Primary Sc...

School year

4

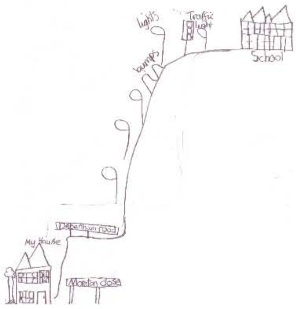
Route - Cartographic Competence

Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number

FE4-031

School

Flamstead End Primary Sc...

School year

4

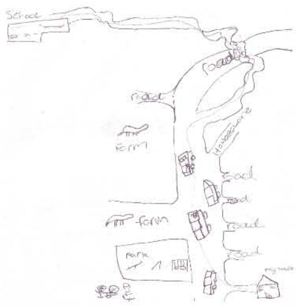
Route - Cartographic Competence

Pictorial

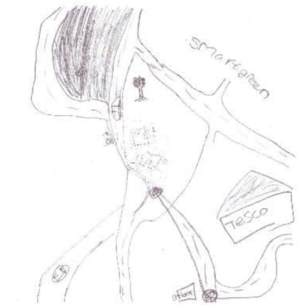
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-034

School

Flamstead End Primary Sc...

School year

4

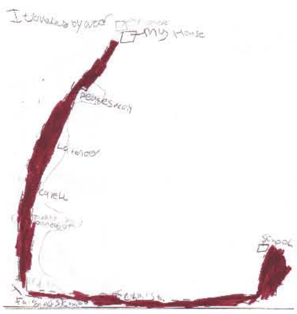
Route - Cartographic Competence

Plan–Pictorial

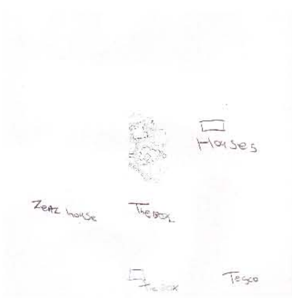
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-025

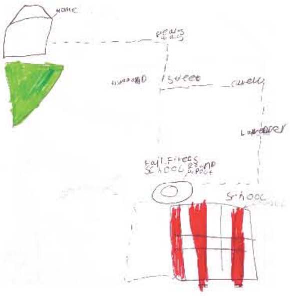
School
Flamstead End Primary Sc...

School year
4

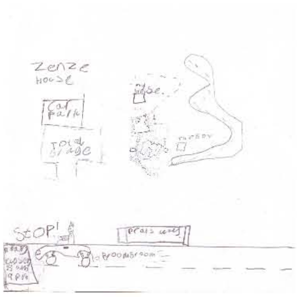
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-006

School
Flamstead End Primary Sc...

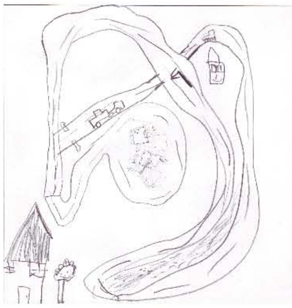
School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number
FE4-055

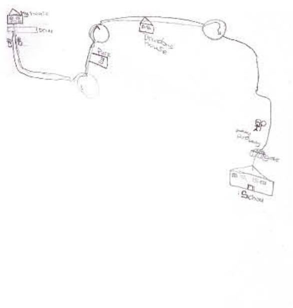
School
Flamstead End Primary Sc...

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number
FE4-054

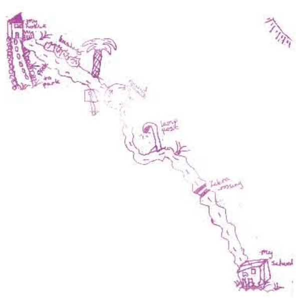
School
Flamstead End Primary Sc...

School year
4

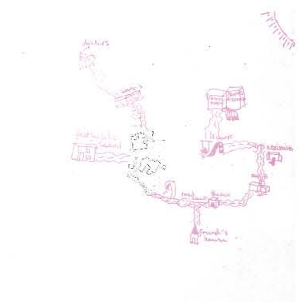
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-016

School

Flamstead End Primary Sc...

School year

4

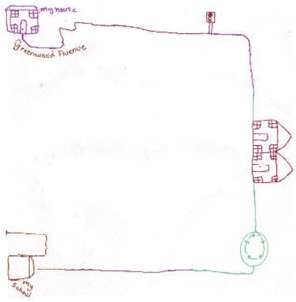
Route - Cartographic Competence

Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number

FE4-001

School

Flamstead End Primary Sc...

School year

4

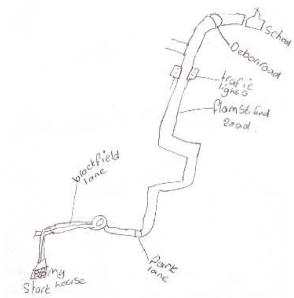
Route - Cartographic Competence

Plan-Pictorial

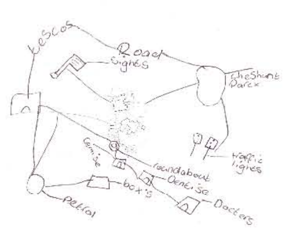
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-039

School

Flamstead End Primary Sc...

School year

4

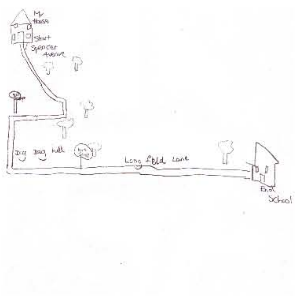
Route - Cartographic Competence

Pictorial

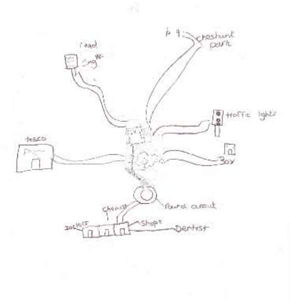
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-015

School

Flamstead End Primary Sc...

School year

4

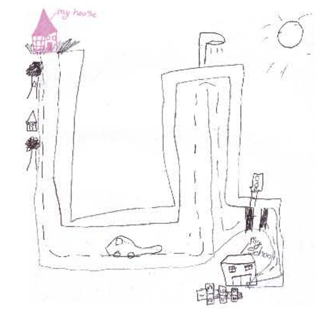
Route - Cartographic Competence

Pictorial

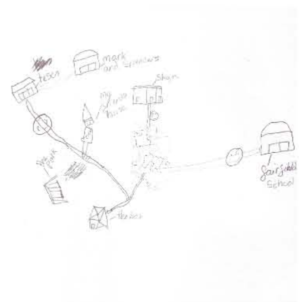
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-047

School

Flamstead End Primary Sc...

School year

4

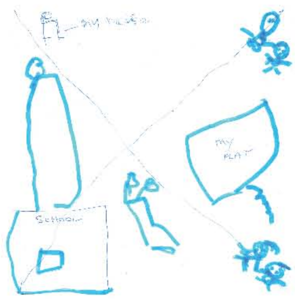
Route - Cartographic Competence

Pictorial

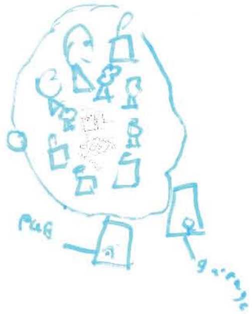
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-057

School

Flamstead End Primary Sc...

School year

4

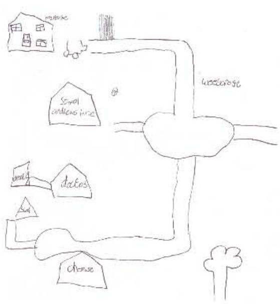
Route - Cartographic Competence

Pictorial

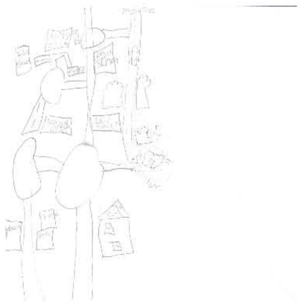
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-007

School

Flamstead End Primary Sc...

School year

4

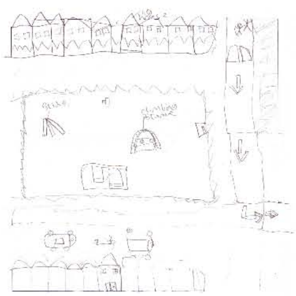
Route - Cartographic Competence

Pictorial

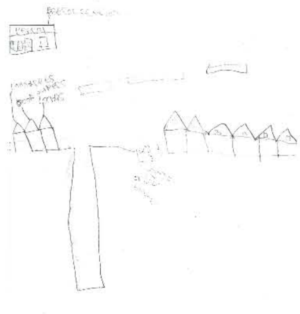
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-046

School

Flamstead End Primary Sc...

School year

4

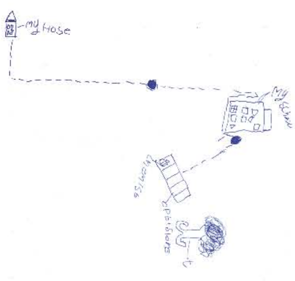
Route - Cartographic Competence

Plan–Pictorial

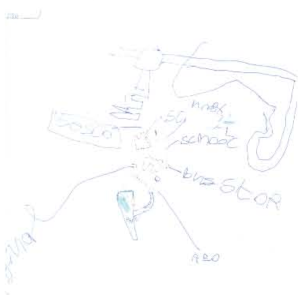
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-041

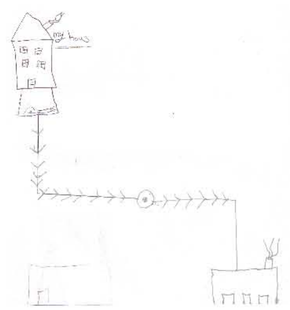
School
Flamstead End Primary Sc...

School year
4

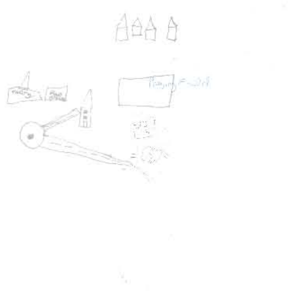
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-042

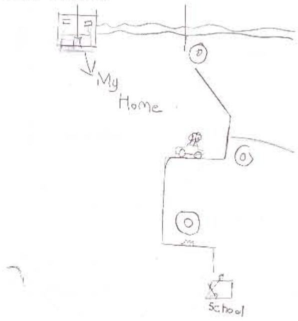
School
Flamstead End Primary Sc...

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number
FE4-017

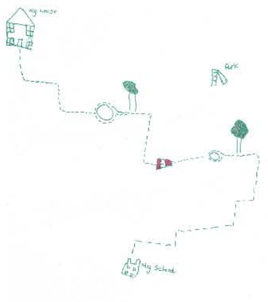
School
Flamstead End Primary Sc...

School year
4

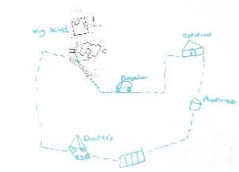
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-048

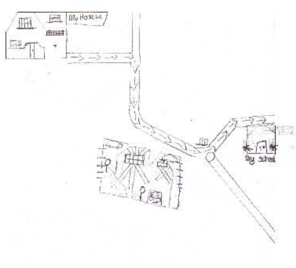
School
Flamstead End Primary Sc...

School year
5

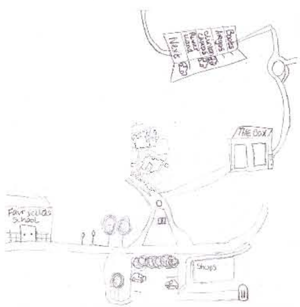
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-047

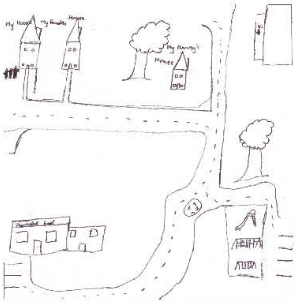
School
Flamstead End Primary Sc...

School year
5

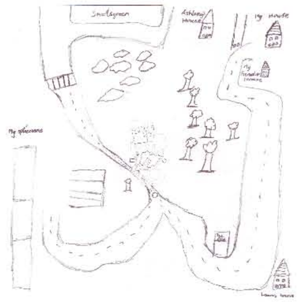
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-010

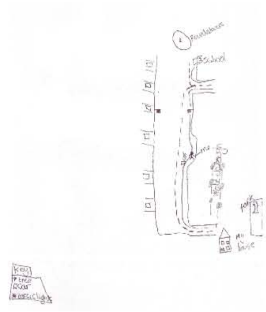
School
Flamstead End Primary Sc...

School year
5

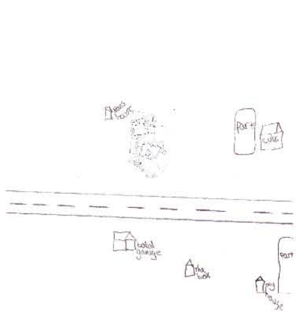
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-054

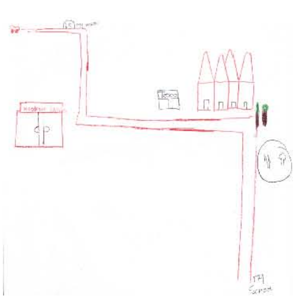
School
Flamstead End Primary Sc...

School year
5

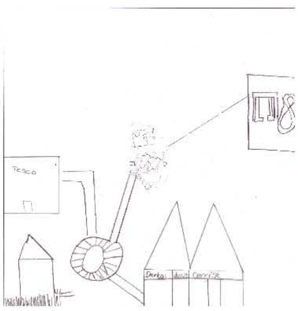
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-055

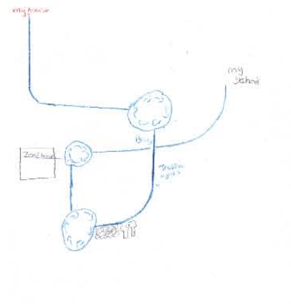
School
Flamstead End Primary Sc...

School year
5

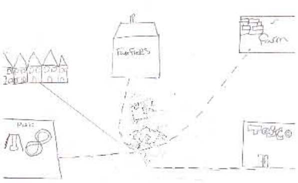
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-038

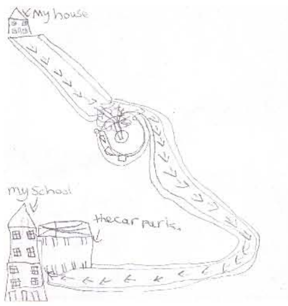
School
Flamstead End Primary Sc...

School year
5

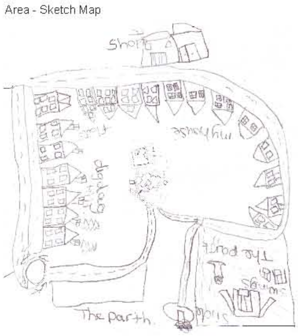
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-041

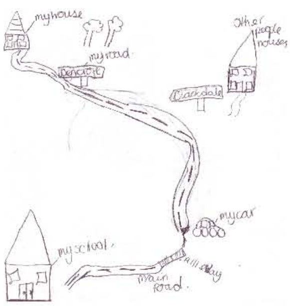
School
Flamstead End Primary Sc...

School year
5

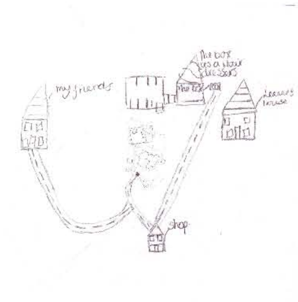
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-052

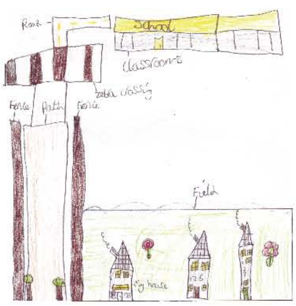
School
Flamstead End Primary Sc...

School year
5

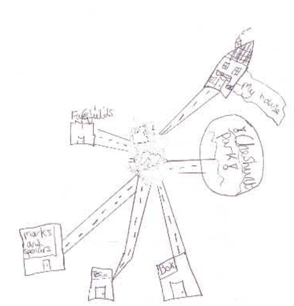
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-061

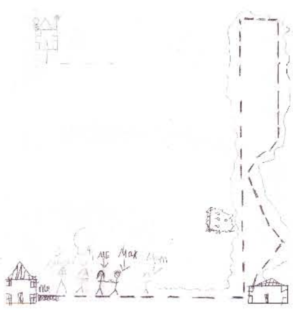
School
Flamstead End Primary Sc...

School year
5

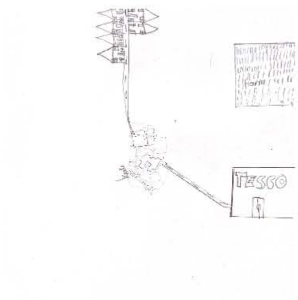
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-043

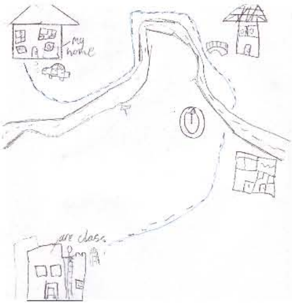
School
Flamstead End Primary Sc...

School year
5

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number
FE5-002

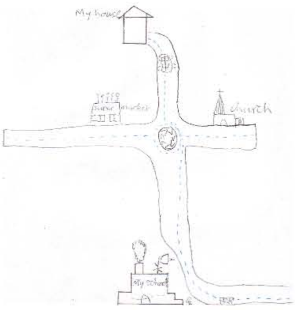
School
Flamstead End Primary Sc...

School year
5

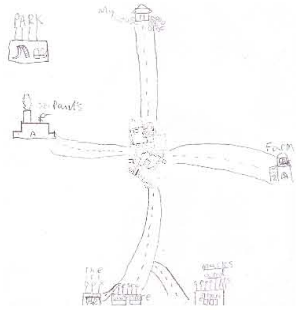
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-009

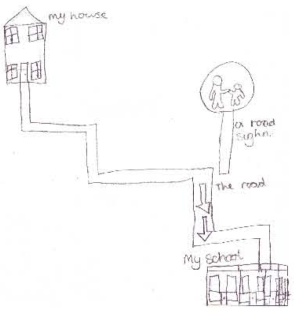
School
Flamstead End Primary Sc...

School year
5

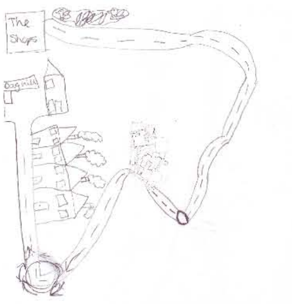
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-056

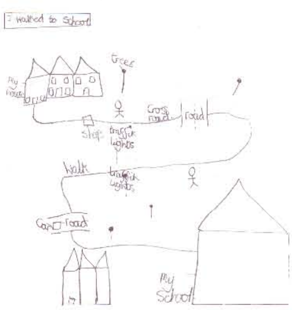
School
Flamstead End Primary Sc...

School year
5

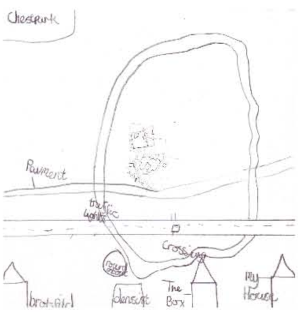
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-051

School

Flamstead End Primary Sc...

School year

5

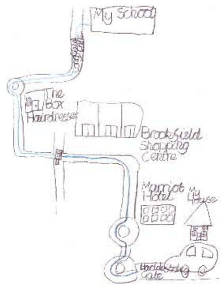
Route - Cartographic Competence

Plan–Pictorial

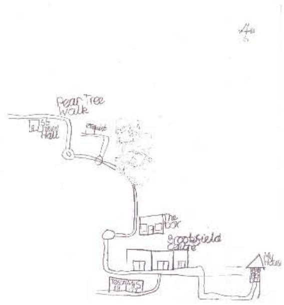
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-027

School

Flamstead End Primary Sc...

School year

5

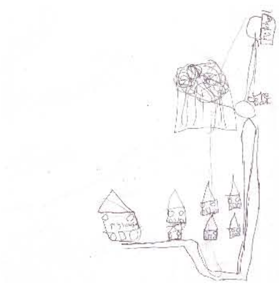
Route - Cartographic Competence

Pictorial

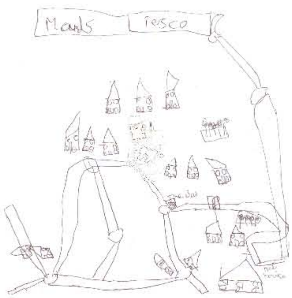
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-029

School

Flamstead End Primary Sc...

School year

5

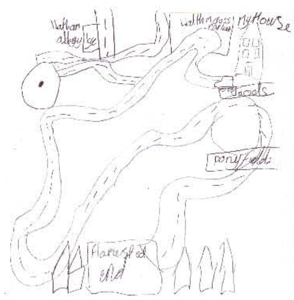
Route - Cartographic Competence

Pictorial

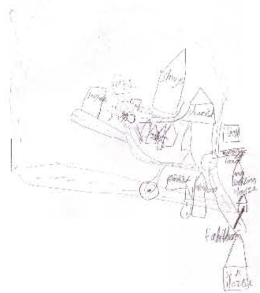
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-015

School

Flamstead End Primary Sc...

School year

5

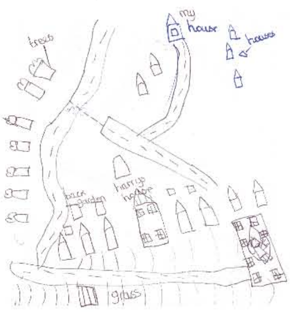
Route - Cartographic Competence

Plan–Pictorial

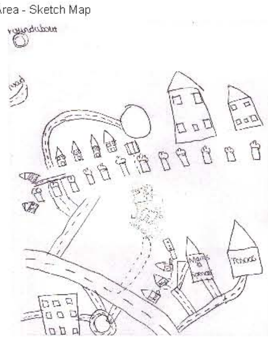
Area - Cartographic Competence

Pictorial

Route - Sketch Map

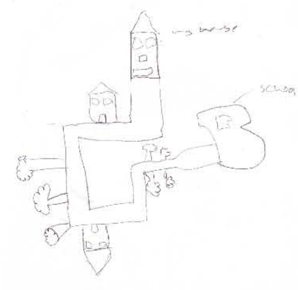


Area - Sketch Map

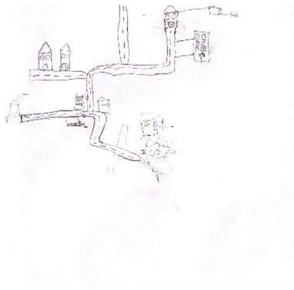


Reference Number
FE5-021
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map



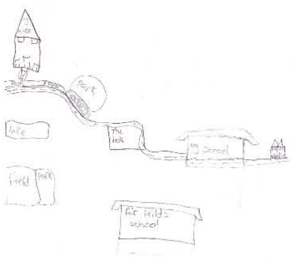
Reference Number
FE5-019
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan-Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map

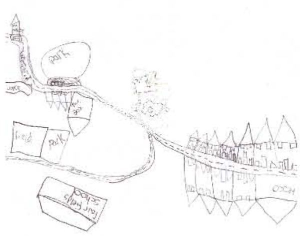
Area - Sketch Map

Reference Number
FE5-028
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan-Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map

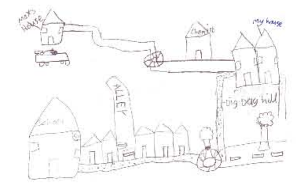


Area - Sketch Map



Reference Number
FE5-018
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number

FE6-035

School

Flamstead End Primary Sc...

School year

6

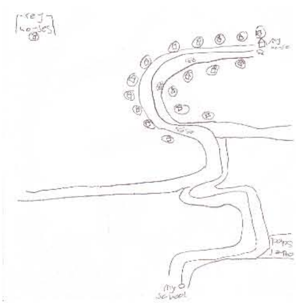
Route - Cartographic Competence

Pictorial

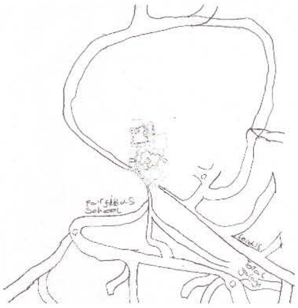
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-036

School

Flamstead End Primary Sc...

School year

6

Route - Cartographic Competence

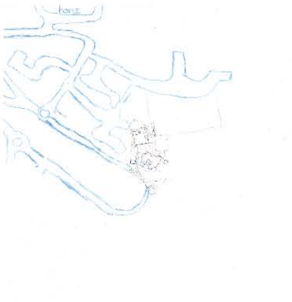
Plan-Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number

FE6-048

School

Flamstead End Primary Sc...

School year

6

Route - Cartographic Competence

Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map

Area - Sketch Map

Reference Number

FE6-037

School

Flamstead End Primary Sc...

School year

6

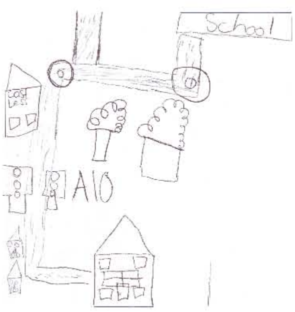
Route - Cartographic Competence

Plan-Pictorial

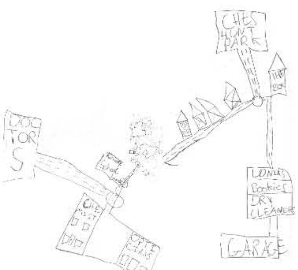
Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-021

School

Flamstead End Primary Sc...

School year

6

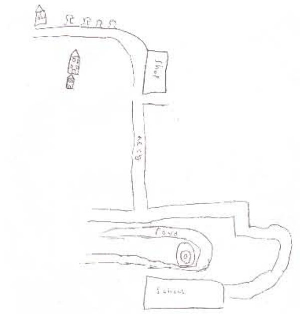
Route - Cartographic Competence

Plan–Pictorial

Area - Cartographic Competence

Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number

FE6-006

School

Flamstead End Primary Sc...

School year

6

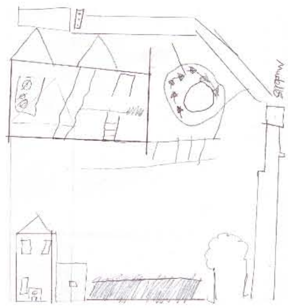
Route - Cartographic Competence

Pictorial

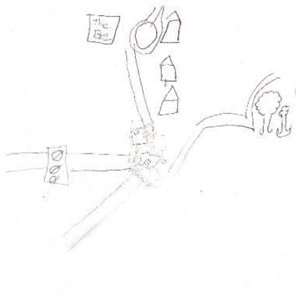
Area - Cartographic Competence

Pictorial

Route - Sketch Map

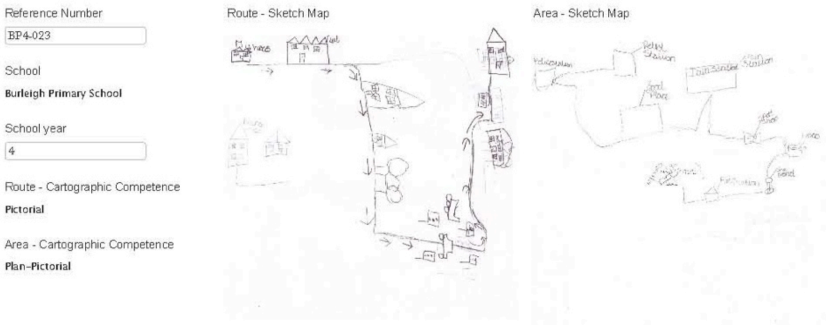


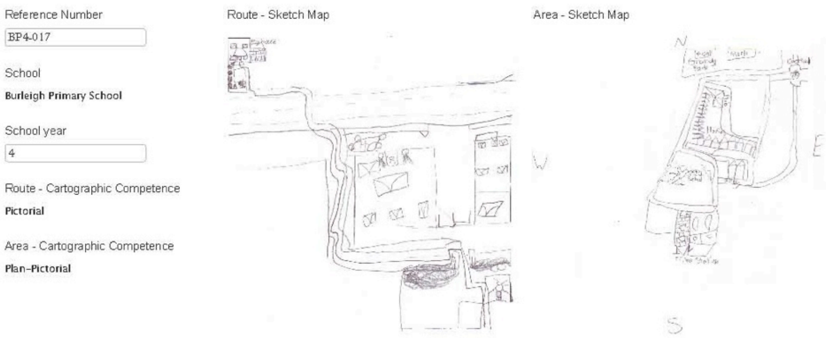
Area - Sketch Map

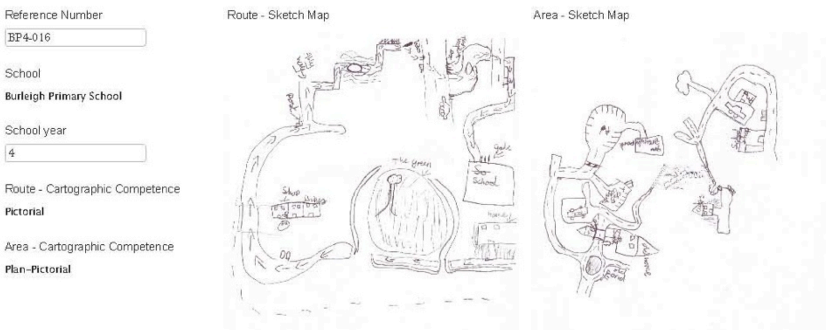


Appendix 8: Plan-pictorial sketch maps

This appendix contains all the sketch maps for children whose area sketch maps have been classified as having been drawn in a mixture of "Plan" and "Pictorial" styles.







Reference Number

BP4-020

School

Burleigh Primary School

School year

4

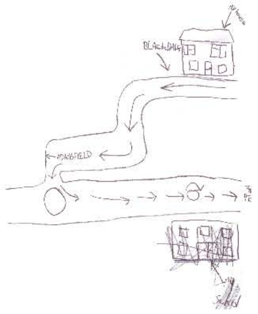
Route - Cartographic Competence

Pictorial

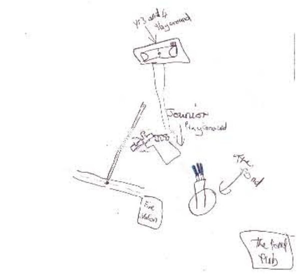
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-019

School

Burleigh Primary School

School year

4

Route - Cartographic Competence

Pictorial

Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map

Area - Sketch Map

Reference Number

BP4-007

School

Burleigh Primary School

School year

4

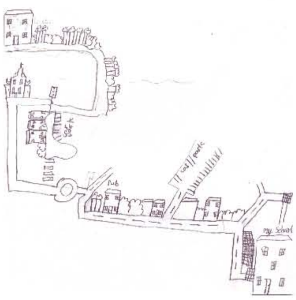
Route - Cartographic Competence

Plan–Pictorial

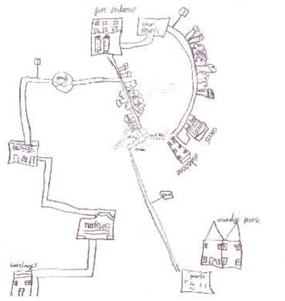
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-027

School

Burleigh Primary School

School year

4

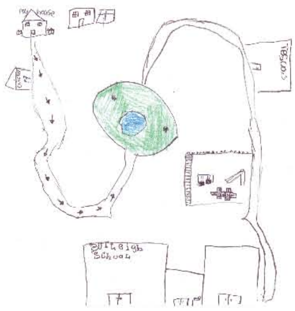
Route - Cartographic Competence

Pictorial

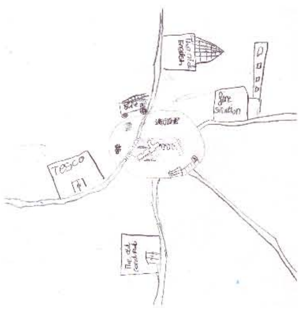
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-026

School

Burleigh Primary School

School year

4

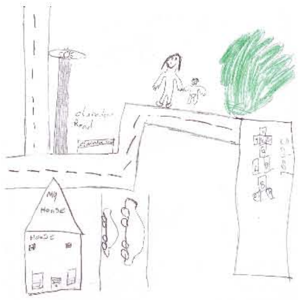
Route - Cartographic Competence

Pictorial

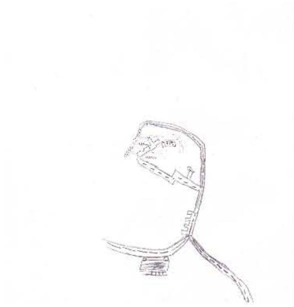
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-008

School

Burleigh Primary School

School year

4

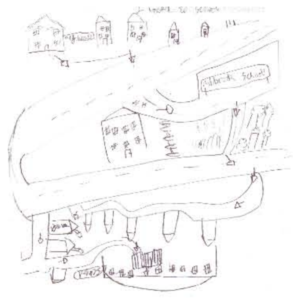
Route - Cartographic Competence

Plan–Pictorial

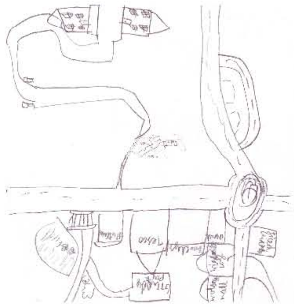
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-033

School

Burleigh Primary School

School year

4

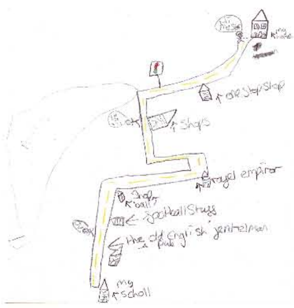
Route - Cartographic Competence

Pictorial

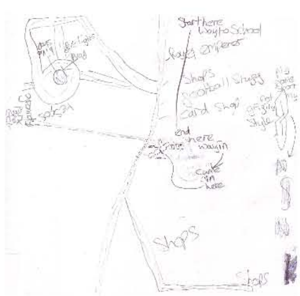
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP4-034

School

Burleigh Primary School

School year

4

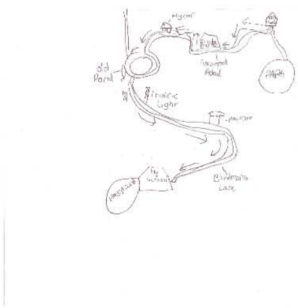
Route - Cartographic Competence

Pictorial

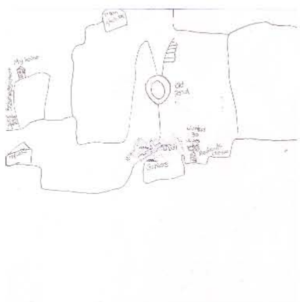
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-030

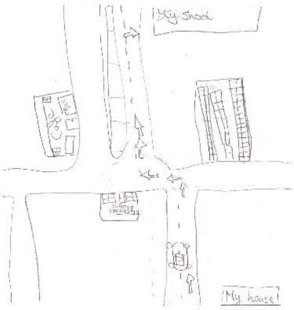
School
Burleigh Primary School

School year
4

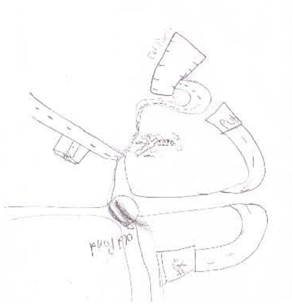
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-047

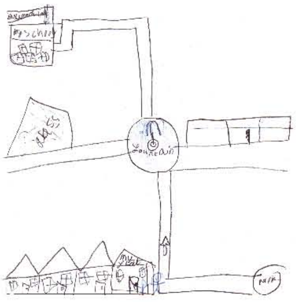
School
Burleigh Primary School

School year
4

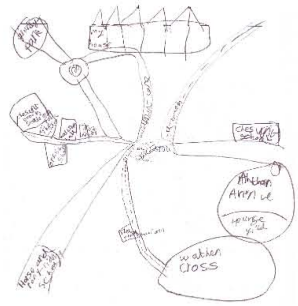
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-056

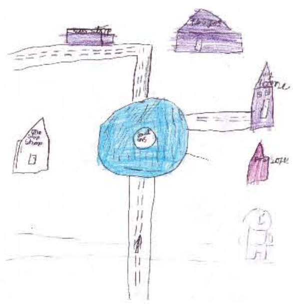
School
Burleigh Primary School

School year
4

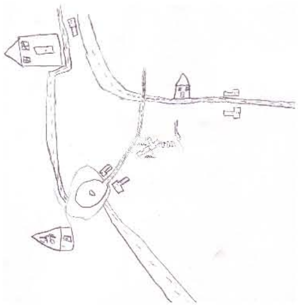
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-035

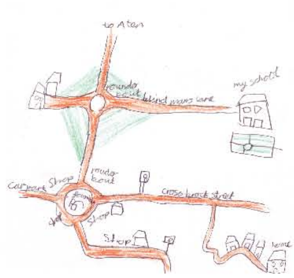
School
Burleigh Primary School

School year
4

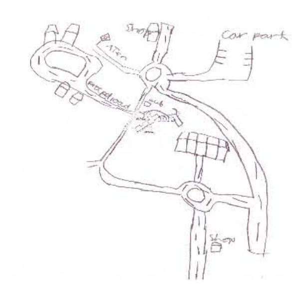
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-040

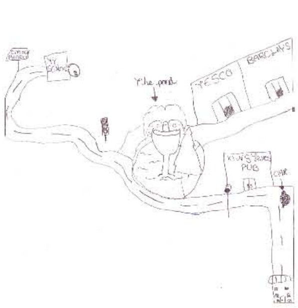
School
Burleigh Primary School

School year
4

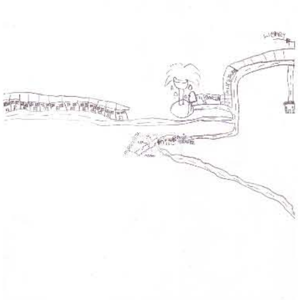
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-054

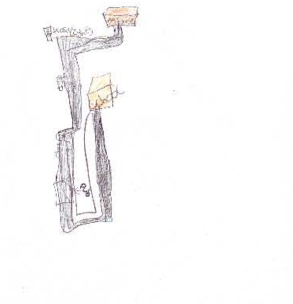
School
Burleigh Primary School

School year
4

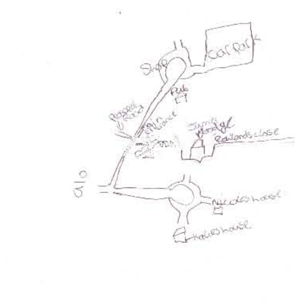
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-017

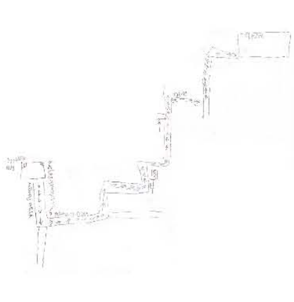
School
Burleigh Primary School

School year
6

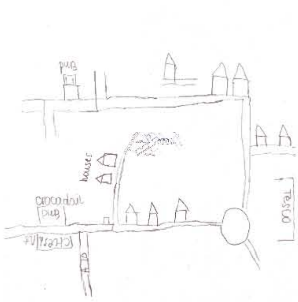
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-018

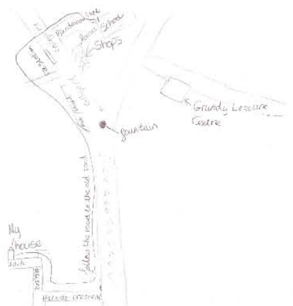
School
Burleigh Primary School

School year
6

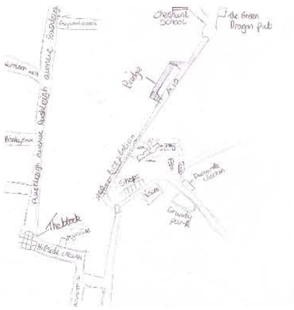
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-004

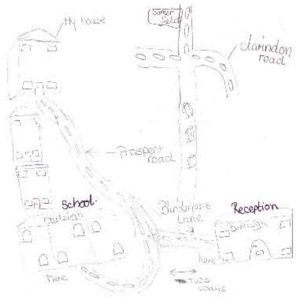
School
Burleigh Primary School

School year
6

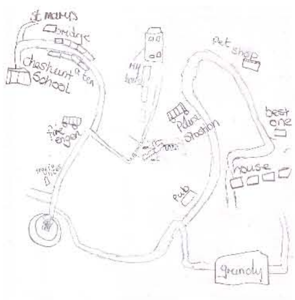
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-013

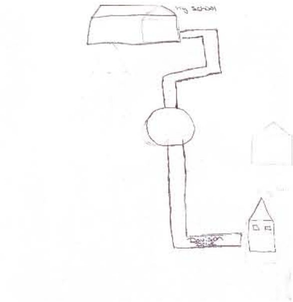
School
Burleigh Primary School

School year
6

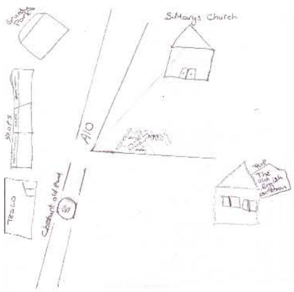
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-034

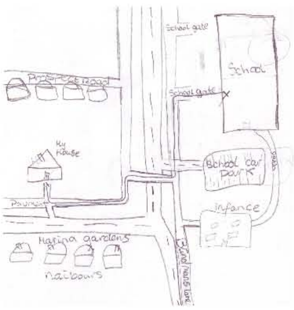
School
Burleigh Primary School

School year
6

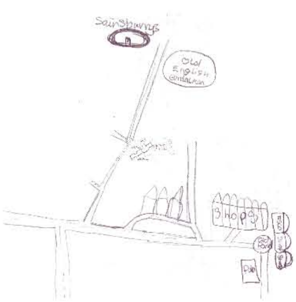
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-025

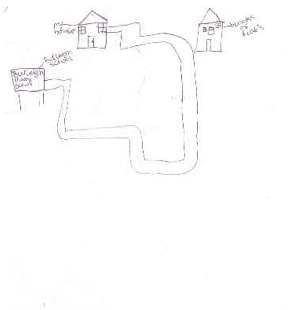
School
Burleigh Primary School

School year
6

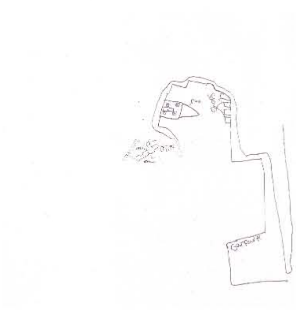
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP6-032

School

Burleigh Primary School

School year

6

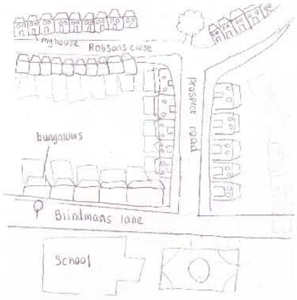
Route - Cartographic Competence

Plan–Pictorial

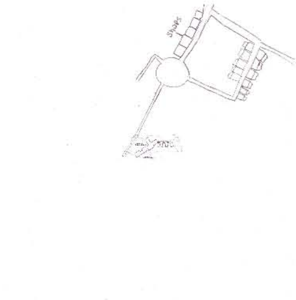
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP6-045

School

Burleigh Primary School

School year

6

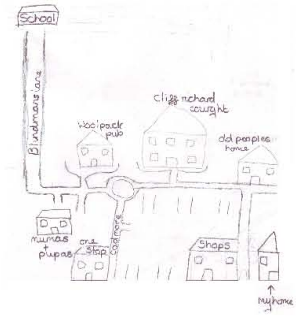
Route - Cartographic Competence

Pictorial

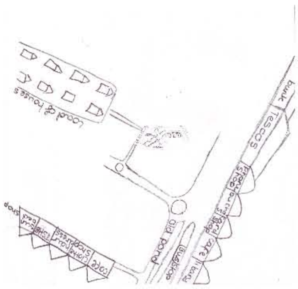
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP6-037

School

Burleigh Primary School

School year

6

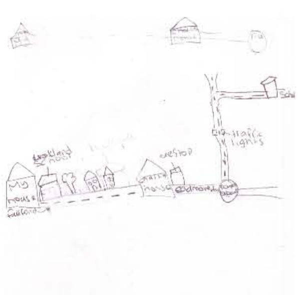
Route - Cartographic Competence

Pictorial

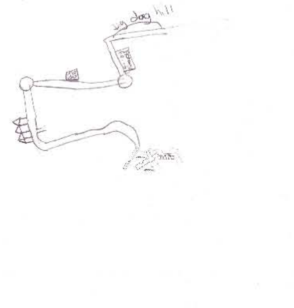
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

BP6-040

School

Burleigh Primary School

School year

6

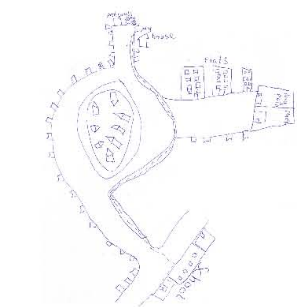
Route - Cartographic Competence

Pictorial

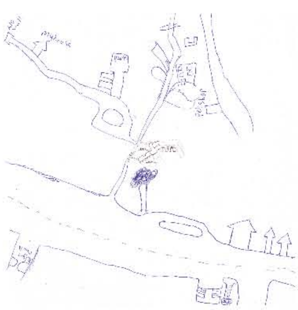
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-039

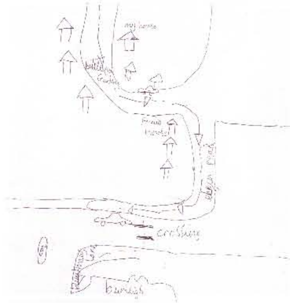
School
Burleigh Primary School

School year
6

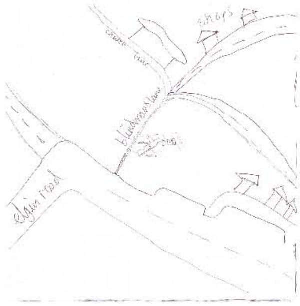
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-021

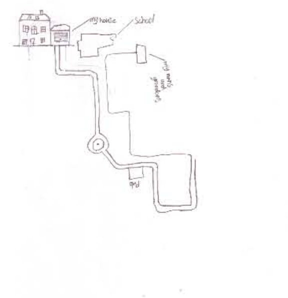
School
Flamstead End Primary Sc...

School year
4

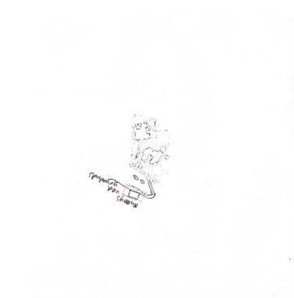
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-037

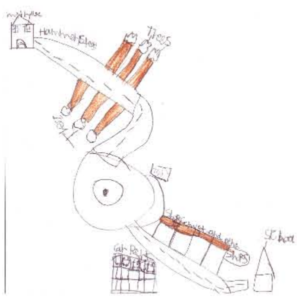
School
Flamstead End Primary Sc...

School year
4

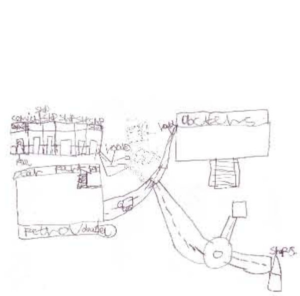
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-013

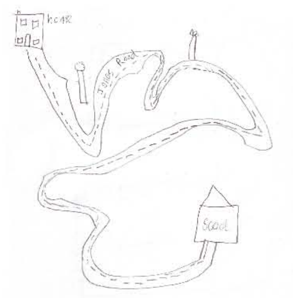
School
Flamstead End Primary Sc...

School year
4

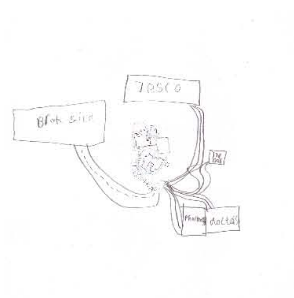
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-004

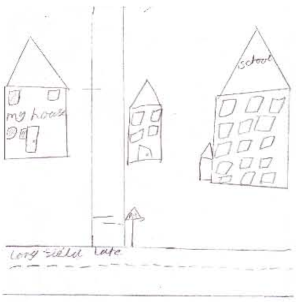
School
Flamstead End Primary Sc...

School year
4

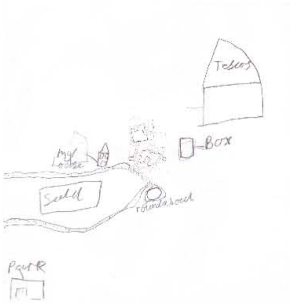
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-011

School
Flamstead End Primary Sc...

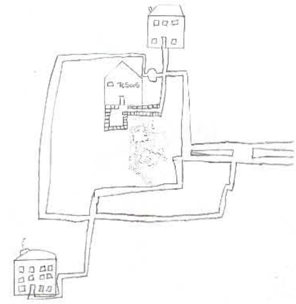
School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number
FE4-022

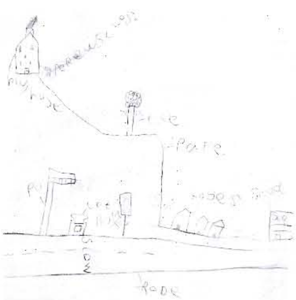
School
Flamstead End Primary Sc...

School year
4

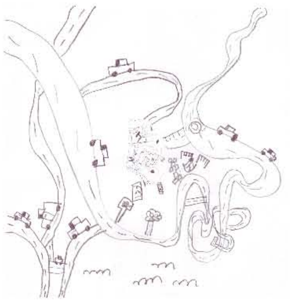
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-026

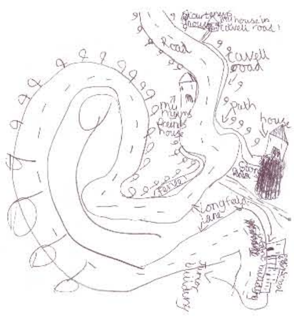
School
Flamstead End Primary Sc...

School year
4

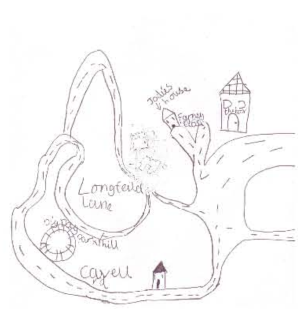
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-029

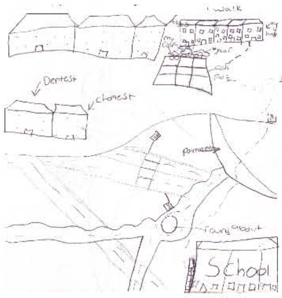
School
Flamstead End Primary Sc...

School year
4

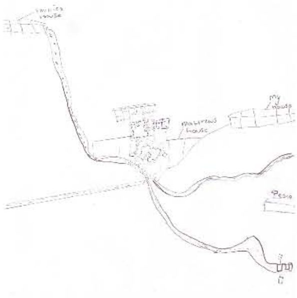
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-020

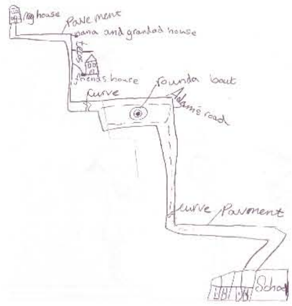
School
Flamstead End Primary Sc...

School year
4

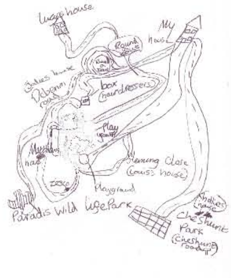
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-030

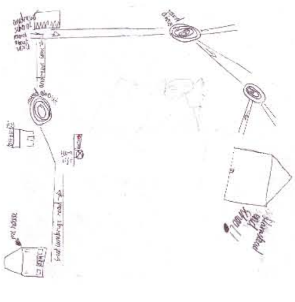
School
Flamstead End Primary Sc...

School year
4

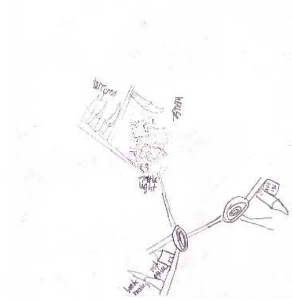
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-038

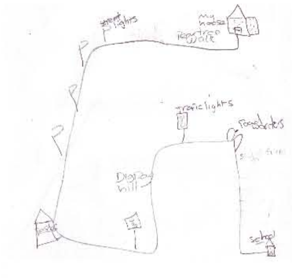
School
Flamstead End Primary Sc...

School year
4

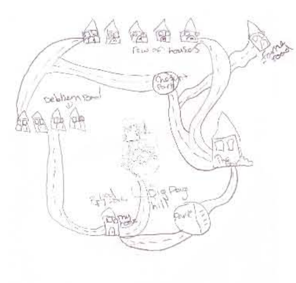
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-048

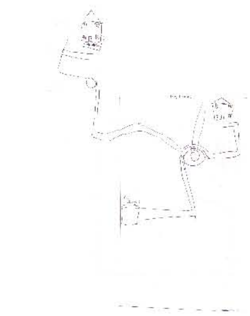
School
Flamstead End Primary Sc...

School year
4

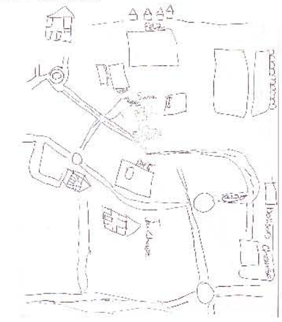
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-050

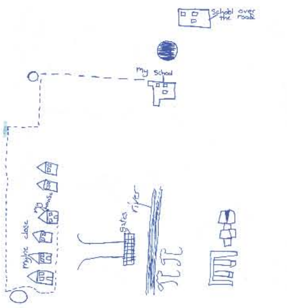
School
Flamstead End Primary Sc...

School year
4

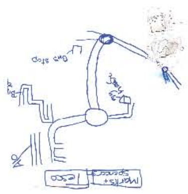
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-002

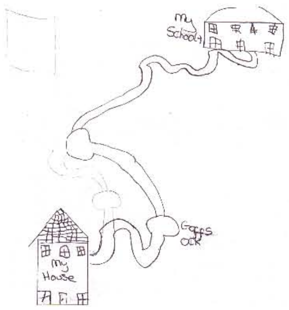
School
Flamstead End Primary Sc...

School year
4

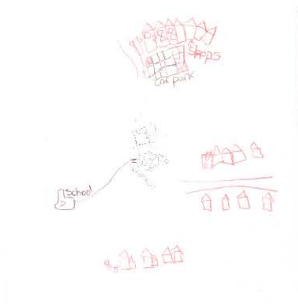
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-045

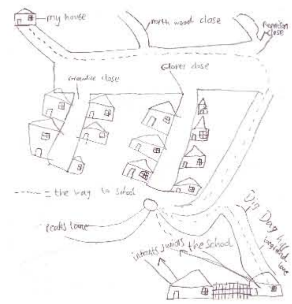
School
Flamstead End Primary Sc...

School year
4

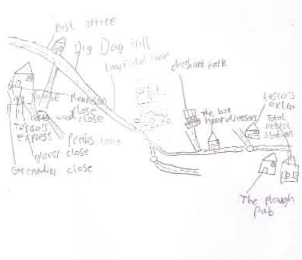
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-051

School

Flamstead End Primary Sc...

School year

4

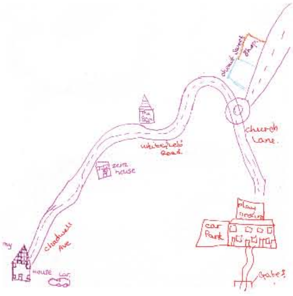
Route - Cartographic Competence

Plan–Pictorial

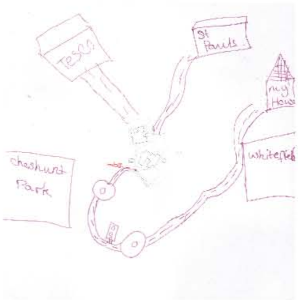
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-052

School

Flamstead End Primary Sc...

School year

4

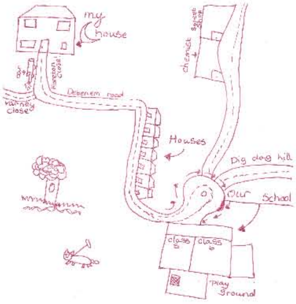
Route - Cartographic Competence

Plan–Pictorial

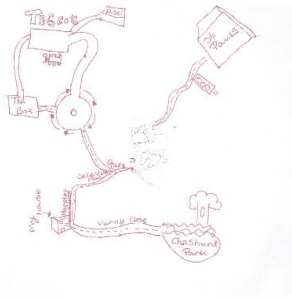
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-053

School

Flamstead End Primary Sc...

School year

4

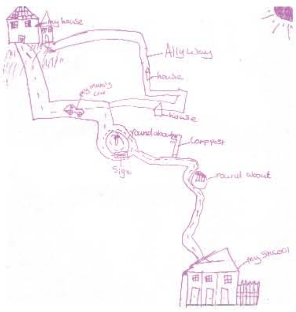
Route - Cartographic Competence

Plan–Pictorial

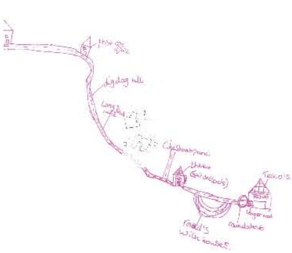
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-049

School

Flamstead End Primary Sc...

School year

4

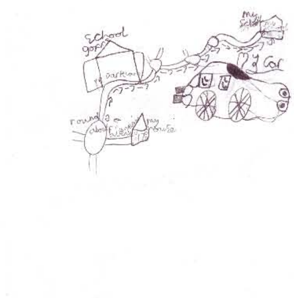
Route - Cartographic Competence

Plan–Pictorial

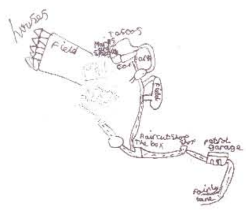
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-009

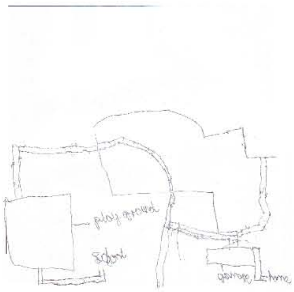
School
Flamstead End Primary Sc...

School year
4

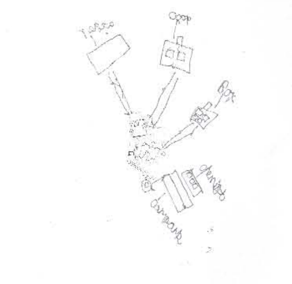
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-045

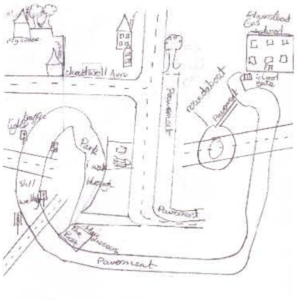
School
Flamstead End Primary Sc...

School year
5

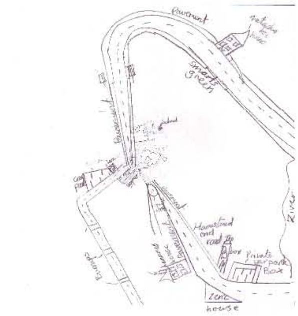
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-058

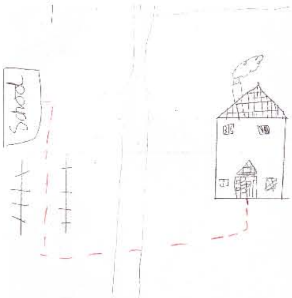
School
Flamstead End Primary Sc...

School year
5

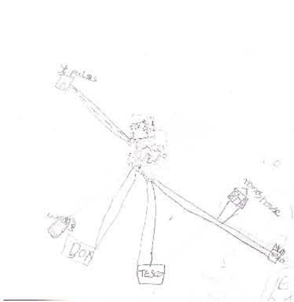
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-044

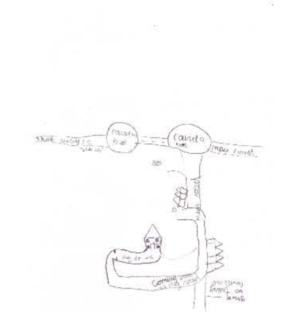
School
Flamstead End Primary Sc...

School year
5

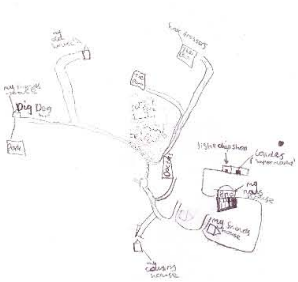
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-011

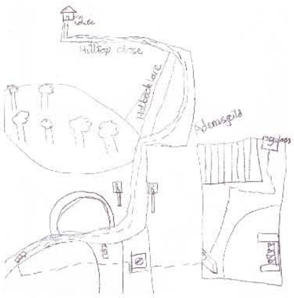
School
Flamstead End Primary Sc...

School year
5

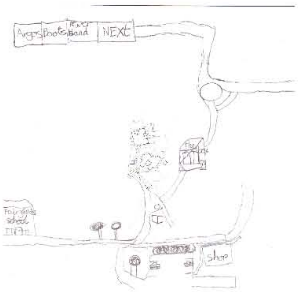
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-060

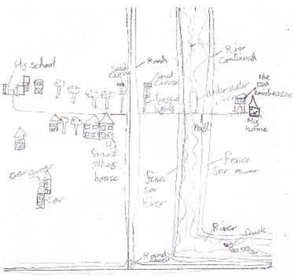
School
Flamstead End Primary Sc...

School year
5

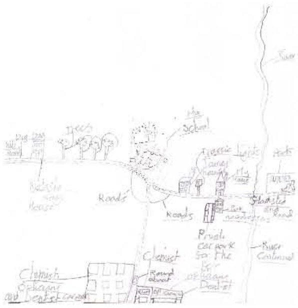
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-050

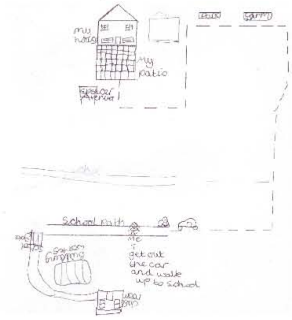
School
Flamstead End Primary Sc...

School year
5

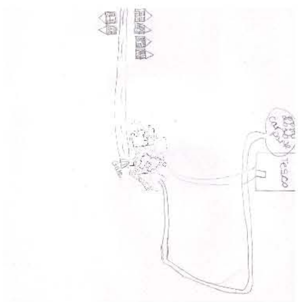
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-053

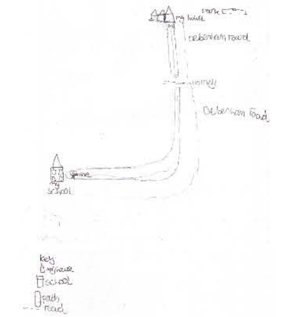
School
Flamstead End Primary Sc...

School year
5

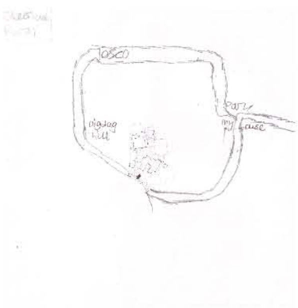
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-049

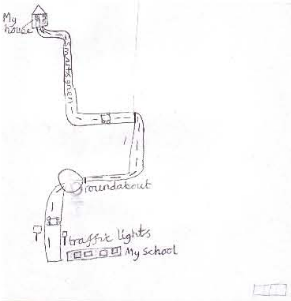
School
Flamstead End Primary Sc...

School year
5

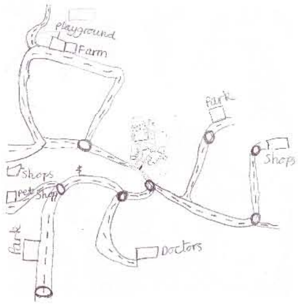
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-039

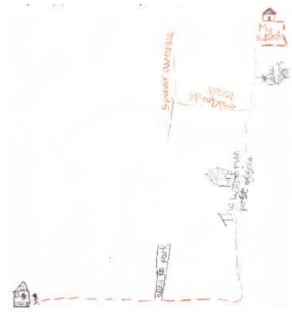
School
Flamstead End Primary Sc...

School year
5

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number
FE5-037

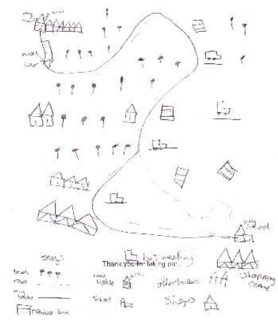
School
Flamstead End Primary Sc...

School year
5

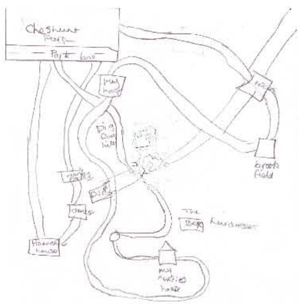
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-024

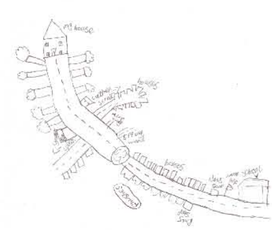
School
Flamstead End Primary Sc...

School year
5

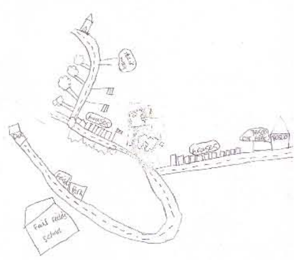
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-030

School

Flamstead End Primary Sc...

School year

5

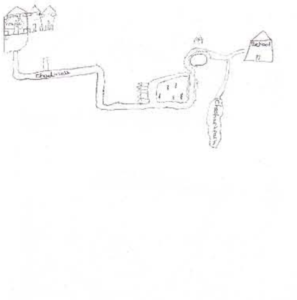
Route - Cartographic Competence

Plan–Pictorial

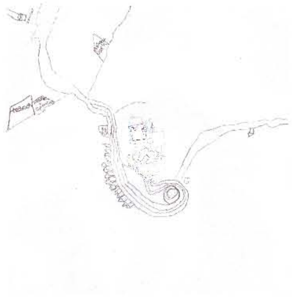
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-001

School

Flamstead End Primary Sc...

School year

5

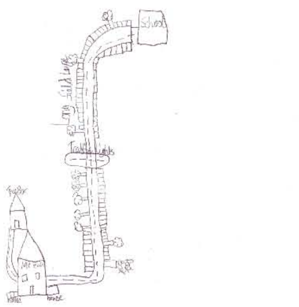
Route - Cartographic Competence

Pictorial

Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map

Reference Number

FE5-020

School

Flamstead End Primary Sc...

School year

5

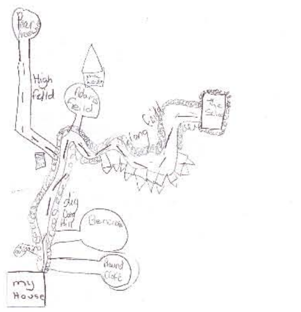
Route - Cartographic Competence

Plan–Pictorial

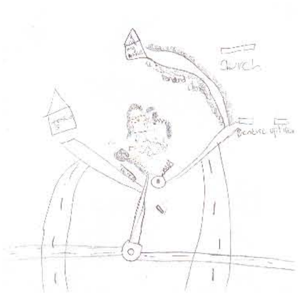
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-016

School

Flamstead End Primary Sc...

School year

5

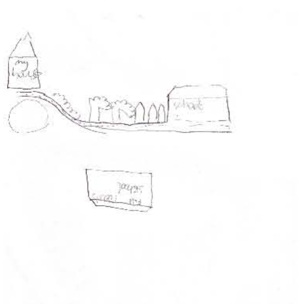
Route - Cartographic Competence

Pictorial

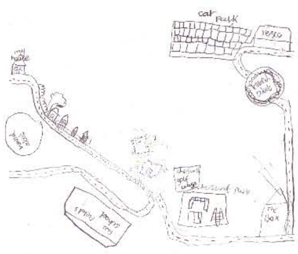
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-023

School

Flamstead End Primary Sc...

School year

5

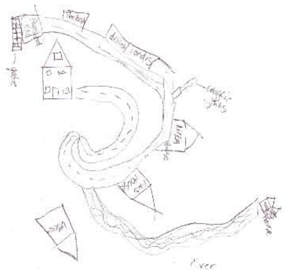
Route - Cartographic Competence

Plan–Pictorial

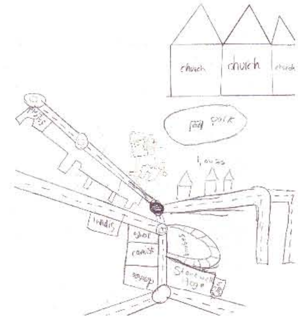
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-033

School

Flamstead End Primary Sc...

School year

5

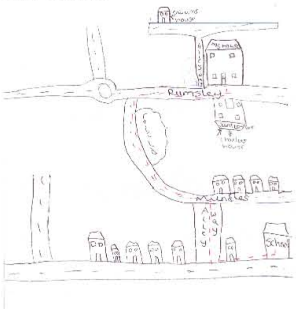
Route - Cartographic Competence

Plan–Pictorial

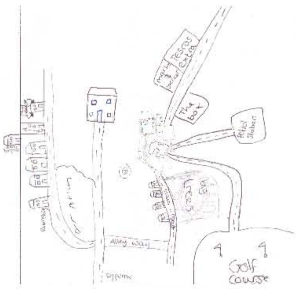
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-006

School

Flamstead End Primary Sc...

School year

5

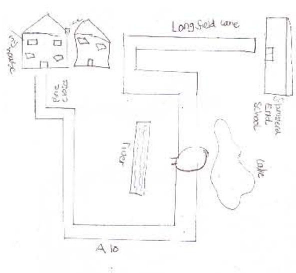
Route - Cartographic Competence

Pictorial

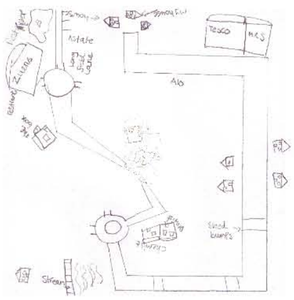
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-017

School

Flamstead End Primary Sc...

School year

5

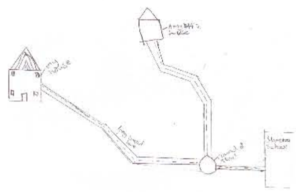
Route - Cartographic Competence

Plan–Pictorial

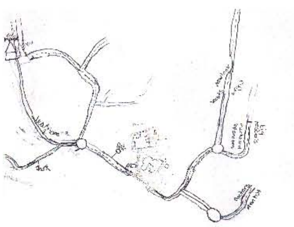
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map

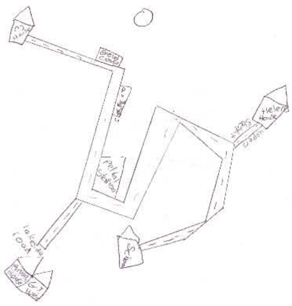


Area - Sketch Map

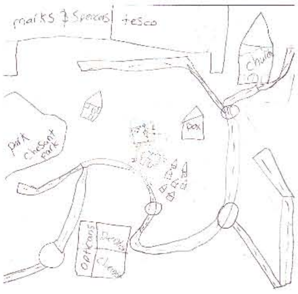


Reference Number
FE5-014
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan–Pictorial
Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



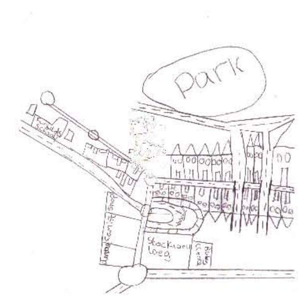
Area - Sketch Map



Reference Number
FE5-032
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan–Pictorial
Area - Cartographic Competence
Plan–Pictorial

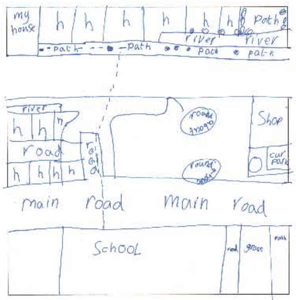
Route - Sketch Map

Area - Sketch Map

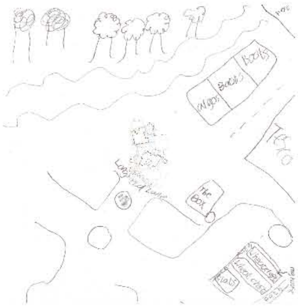


Reference Number
FE6-032
School
Flamstead End Primary Sc...
School year
6
Route - Cartographic Competence
Plan
Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map

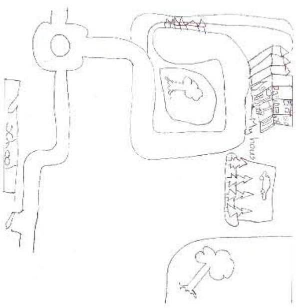


Area - Sketch Map

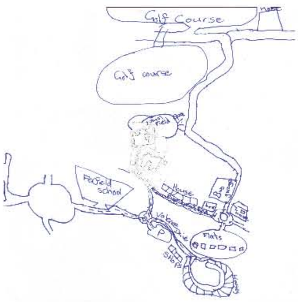


Reference Number
FE6-013
School
Flamstead End Primary Sc...
School year
6
Route - Cartographic Competence
Plan–Pictorial
Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-043

School

Flamstead End Primary Sc...

School year

6

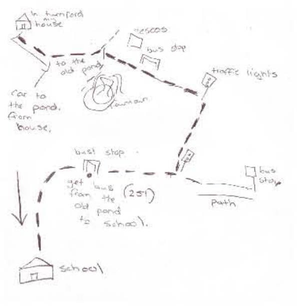
Route - Cartographic Competence

Pictorial

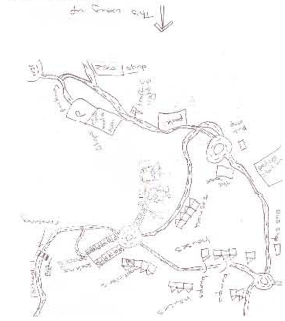
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-012

School

Flamstead End Primary Sc...

School year

6

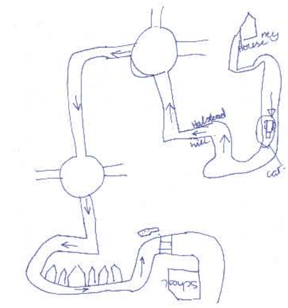
Route - Cartographic Competence

Plan–Pictorial

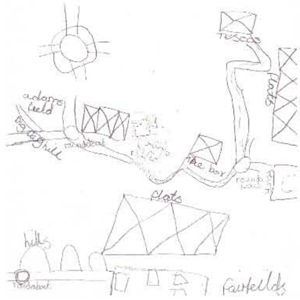
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-033

School

Flamstead End Primary Sc...

School year

6

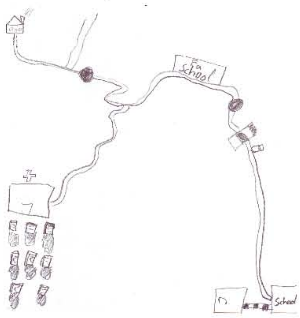
Route - Cartographic Competence

Pictorial

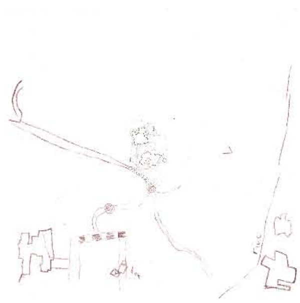
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-031

School

Flamstead End Primary Sc...

School year

6

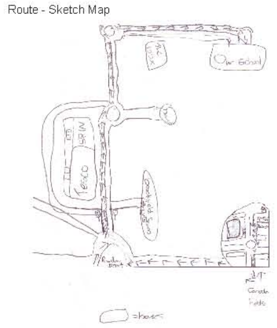
Route - Cartographic Competence

Plan

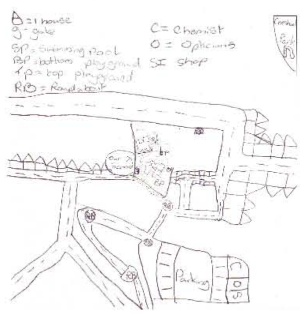
Area - Cartographic Competence

Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-011

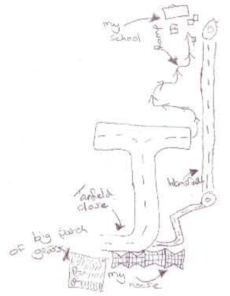
School
Flamstead End Primary Sc...

School year
6

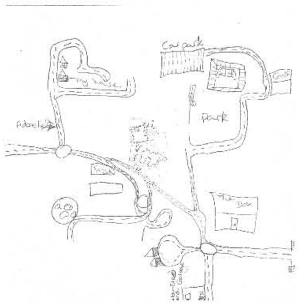
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
No Ref

School
Flamstead End Primary Sc...

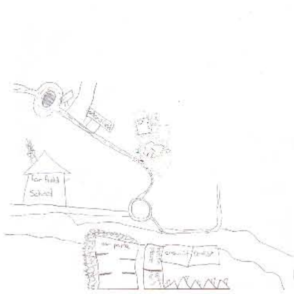
School year
6

Route - Cartographic Competence
No Map

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-040

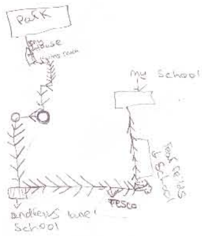
School
Flamstead End Primary Sc...

School year
6

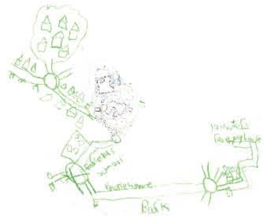
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-045

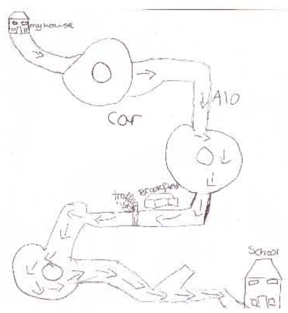
School
Flamstead End Primary Sc...

School year
6

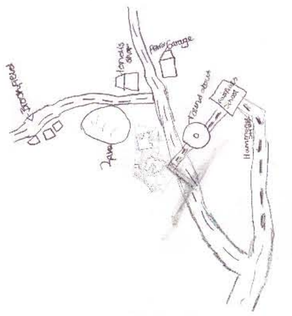
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-005

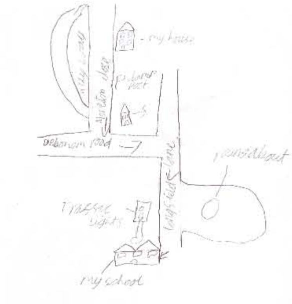
School
Flamstead End Primary Sc...

School year
6

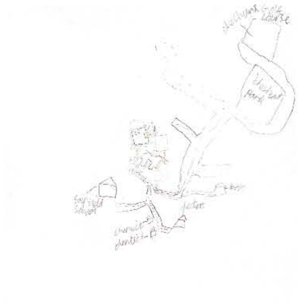
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-052

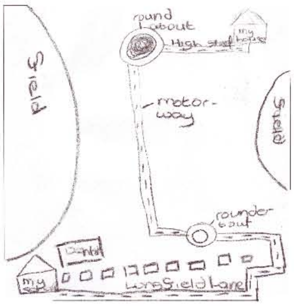
School
Flamstead End Primary Sc...

School year
6

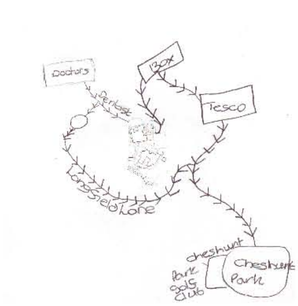
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-028

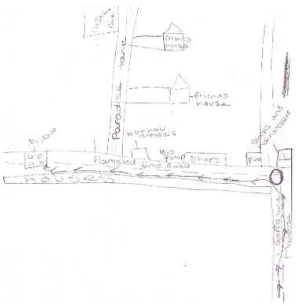
School
Flamstead End Primary Sc...

School year
6

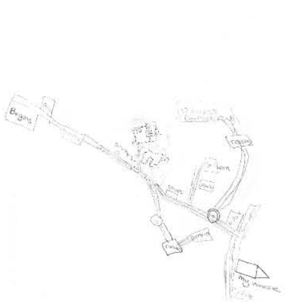
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-020

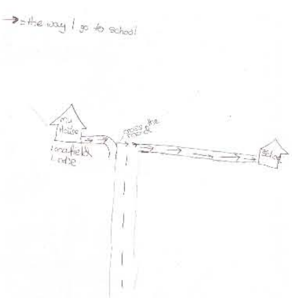
School
Flamstead End Primary Sc...

School year
6

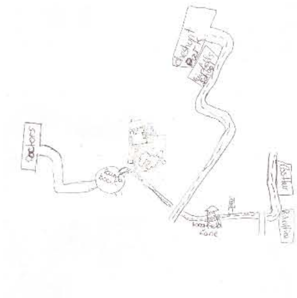
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-022

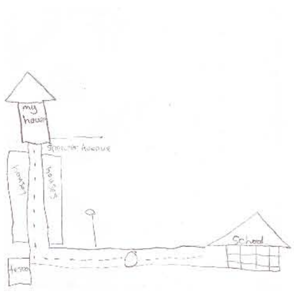
School
Flamstead End Primary Sc...

School year
6

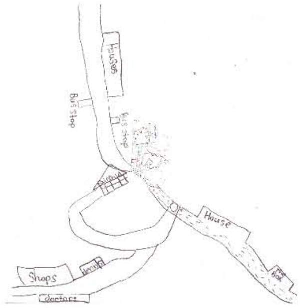
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-018

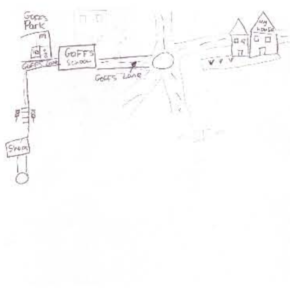
School
Flamstead End Primary Sc...

School year
6

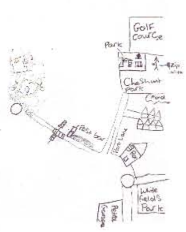
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-017

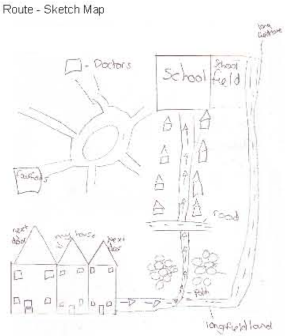
School
Flamstead End Primary Sc...

School year
6

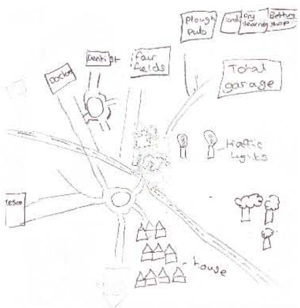
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-024

School
Flamstead End Primary Sc...

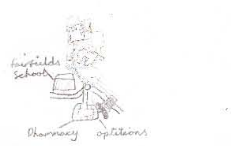
School year
6

Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number

FE6-010

School

Flamstead End Primary Sc...

School year

6

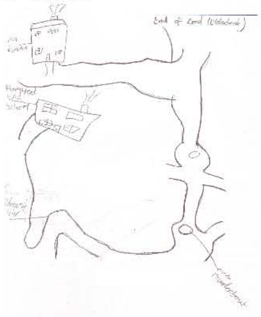
Route - Cartographic Competence

Plan-Pictorial

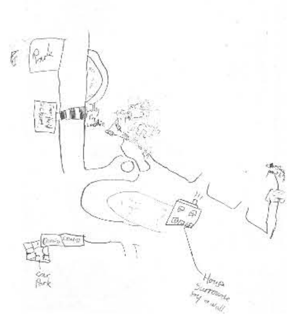
Area - Cartographic Competence

Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-053

School

Flamstead End Primary Sc...

School year

6

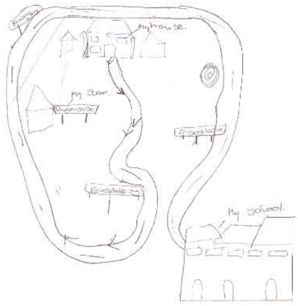
Route - Cartographic Competence

Pictorial

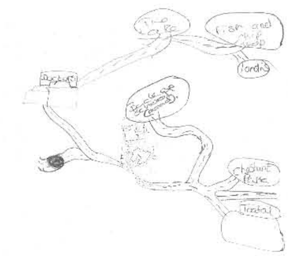
Area - Cartographic Competence

Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-049

School

Flamstead End Primary Sc...

School year

6

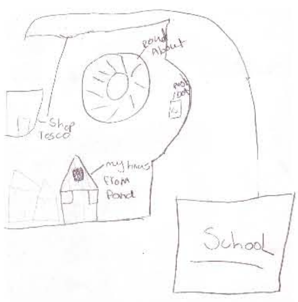
Route - Cartographic Competence

Plan-Pictorial

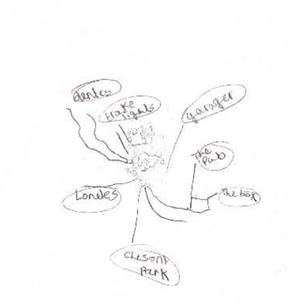
Area - Cartographic Competence

Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number

FE6-051

School

Flamstead End Primary Sc...

School year

6

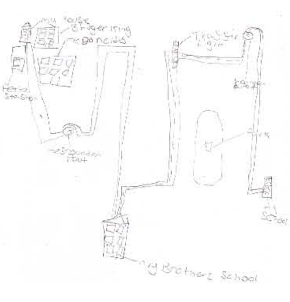
Route - Cartographic Competence

Plan-Pictorial

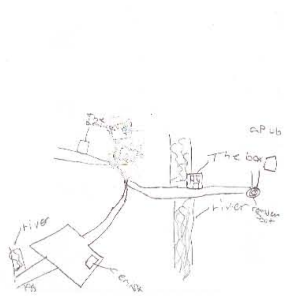
Area - Cartographic Competence

Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-050

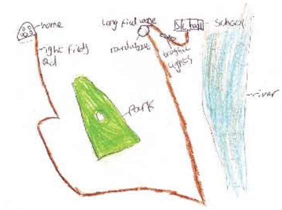
School
Flamstead End Primary Sc...

School year
6

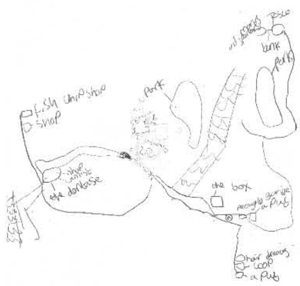
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-055

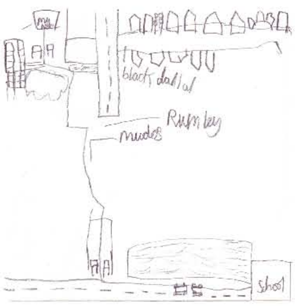
School
Flamstead End Primary Sc...

School year
6

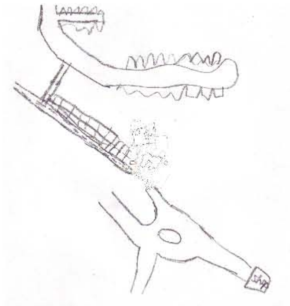
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-056

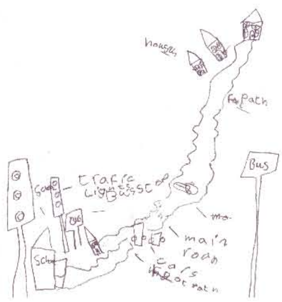
School
Flamstead End Primary Sc...

School year
6

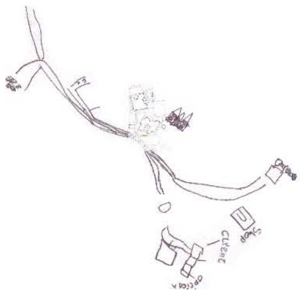
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-019

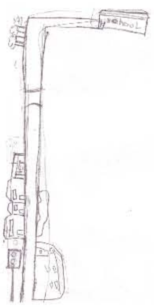
School
Flamstead End Primary Sc...

School year
6

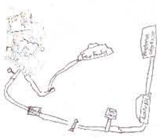
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan–Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-058

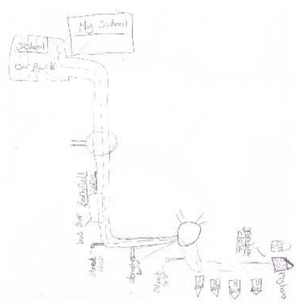
School
Flamstead End Primary Sc...

School year
6

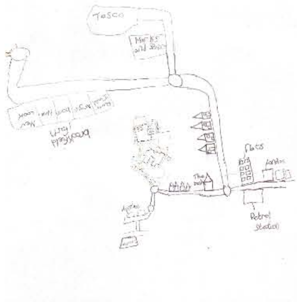
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-057

School
Flamstead End Primary Sc...

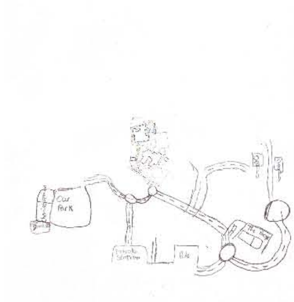
School year
6

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-001

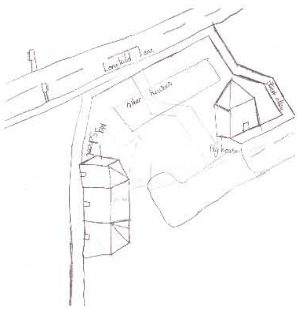
School
Flamstead End Primary Sc...

School year
6

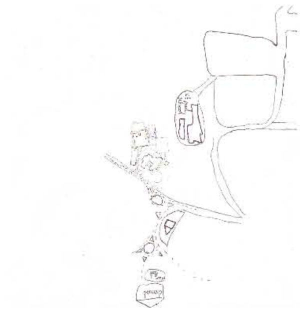
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-027

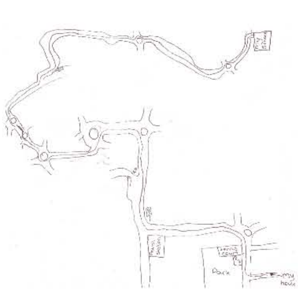
School
Flamstead End Primary Sc...

School year
6

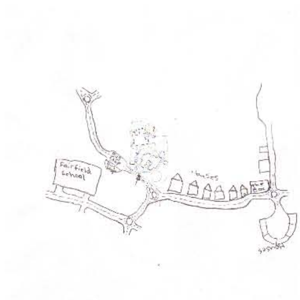
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan-Pictorial

Route - Sketch Map



Area - Sketch Map



Appendix 9: Plan sketch maps

This appendix contains all the sketch maps for children whose area sketch maps have been classified as having been drawn in a "Plan" style.

Reference Number
BP4-015

School
Burleigh Primary School

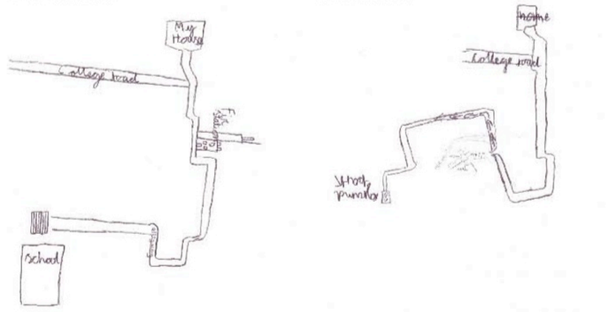
School year
4

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP4-037

School
Burleigh Primary School

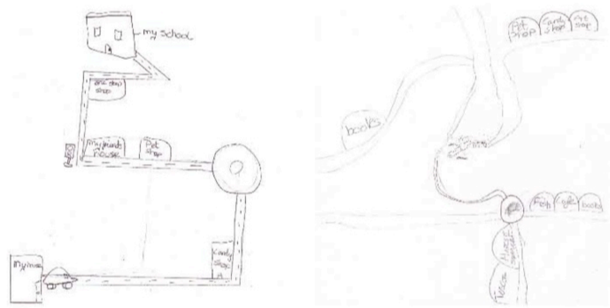
School year
4

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP4-046

School
Burleigh Primary School

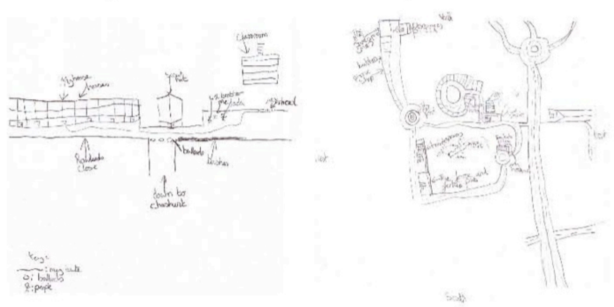
School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP4-036

School
Burleigh Primary School

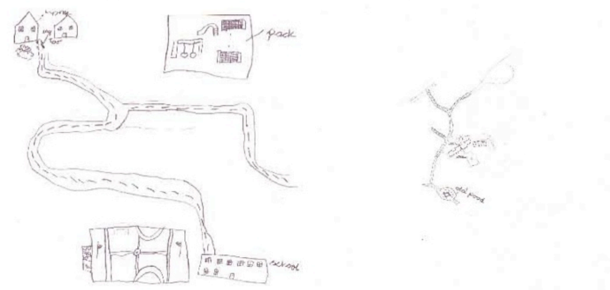
School year
4

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP4-051

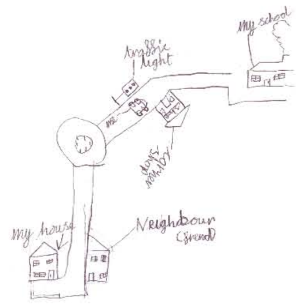
School
Burleigh Primary School

School year
4

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
BP4-043

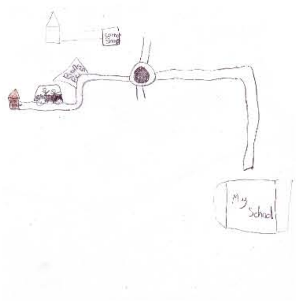
School
Burleigh Primary School

School year
4

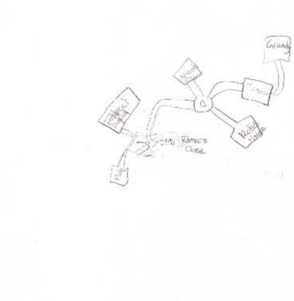
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP4-041

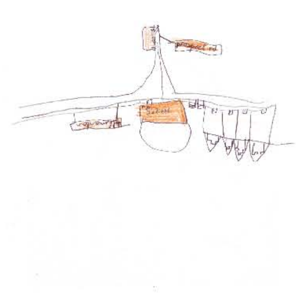
School
Burleigh Primary School

School year
4

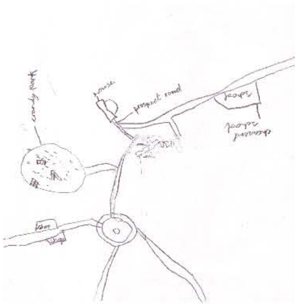
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-016

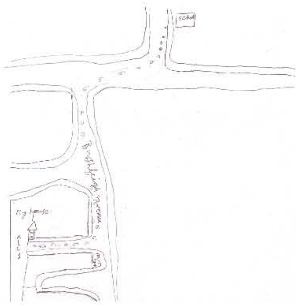
School
Burleigh Primary School

School year
6

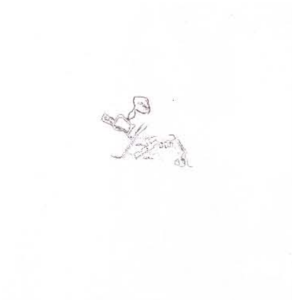
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-049

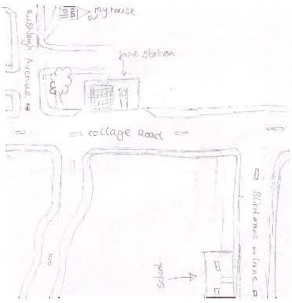
School
Burleigh Primary School

School year
6

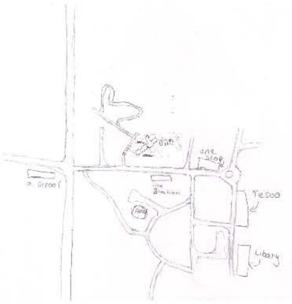
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-014

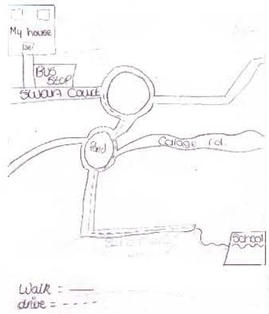
School
Burleigh Primary School

School year
6

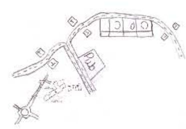
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-015

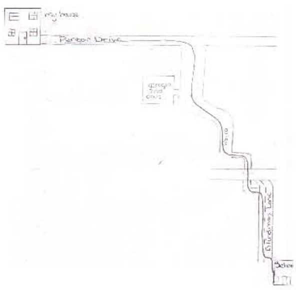
School
Burleigh Primary School

School year
6

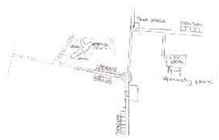
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-002

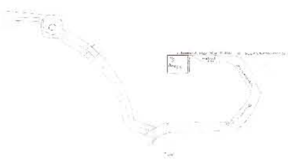
School
Burleigh Primary School

School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number

BP6-006

School

Burleigh Primary School

School year

6

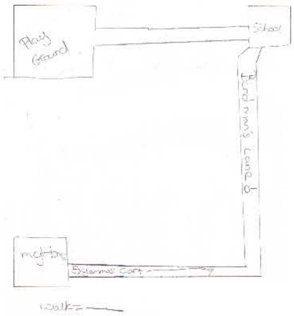
Route - Cartographic Competence

Plan

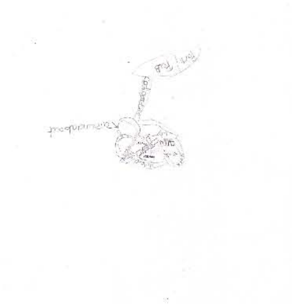
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

No Ref

School

Burleigh Primary School

School year

6

Route - Cartographic Competence

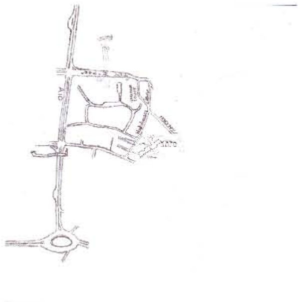
No Map

Area - Cartographic Competence

Plan

Route - Sketch Map

Area - Sketch Map



Reference Number

BP6-010

School

Burleigh Primary School

School year

6

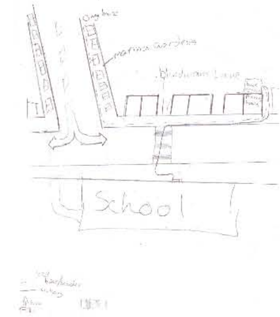
Route - Cartographic Competence

Plan

Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map

Reference Number

BP6-009

School

Burleigh Primary School

School year

6

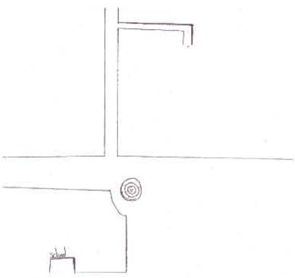
Route - Cartographic Competence

Plan

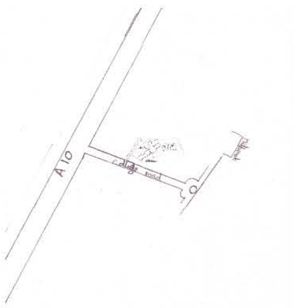
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-001

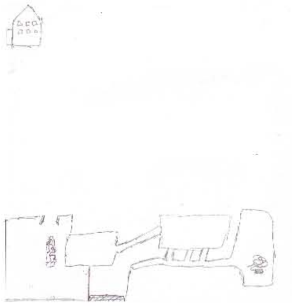
School
Burleigh Primary School

School year
6

Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
BP6-011

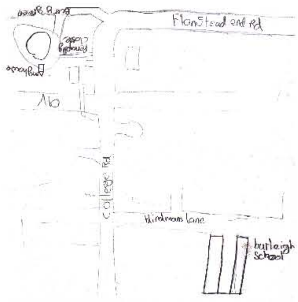
School
Burleigh Primary School

School year
6

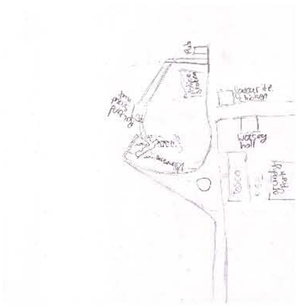
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-012

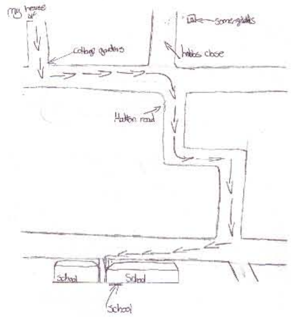
School
Burleigh Primary School

School year
6

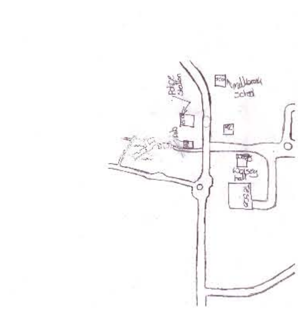
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-047

School
Burleigh Primary School

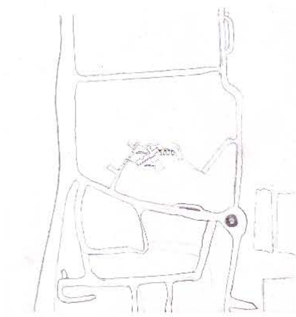
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP6-003

School
Burleigh Primary School

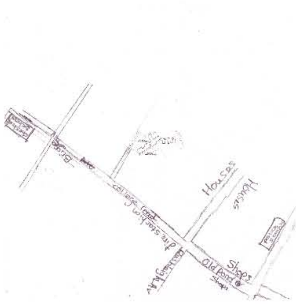
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP6-020

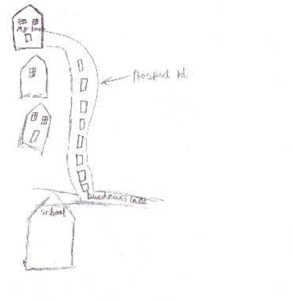
School
Burleigh Primary School

School year
6

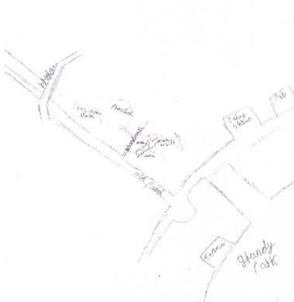
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-048

School
Burleigh Primary School

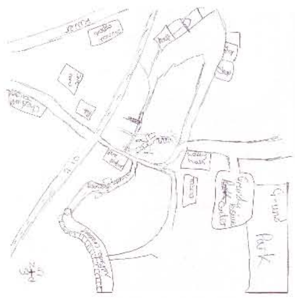
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP6-008

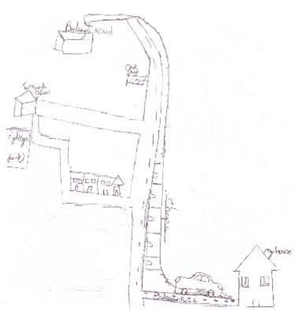
School
Burleigh Primary School

School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
BP6-007

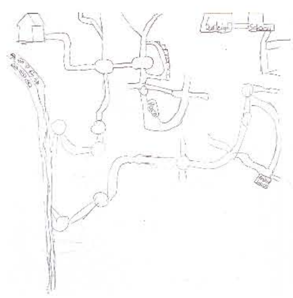
School
Burleigh Primary School

School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
BP6-019

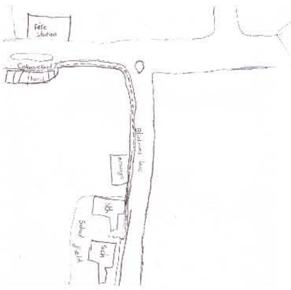
School
Burleigh Primary School

School year
6

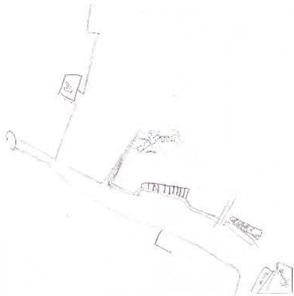
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-005

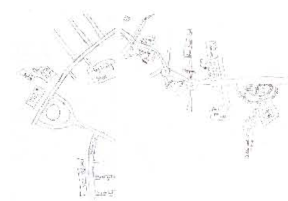
School
Burleigh Primary School

School year
6

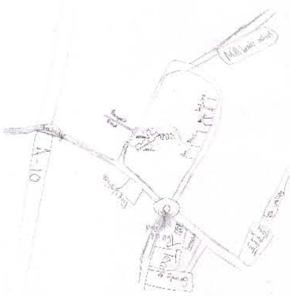
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-035

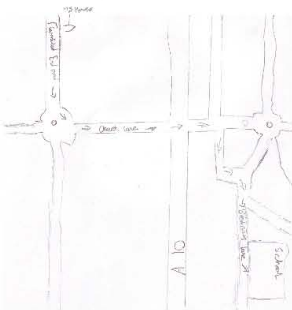
School
Burleigh Primary School

School year
6

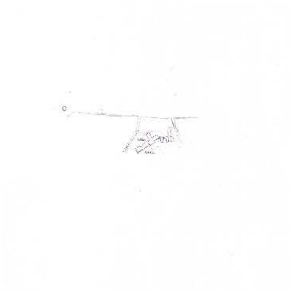
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-021

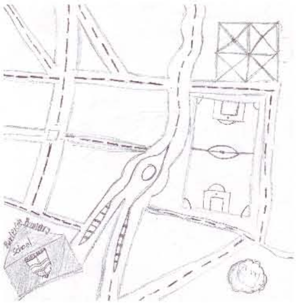
School
Burleigh Primary School

School year
6

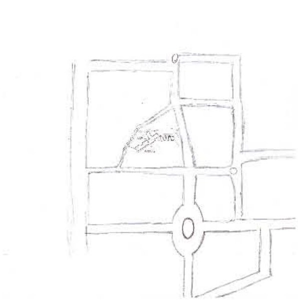
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-042

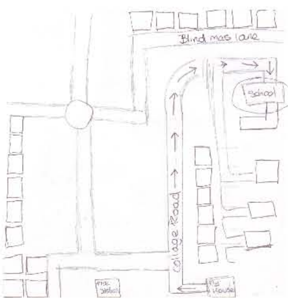
School
Burleigh Primary School

School year
6

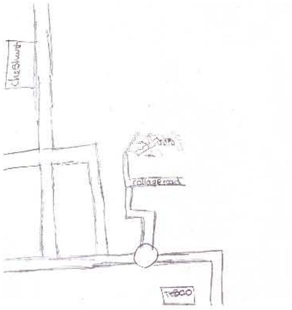
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-043

School
Burleigh Primary School

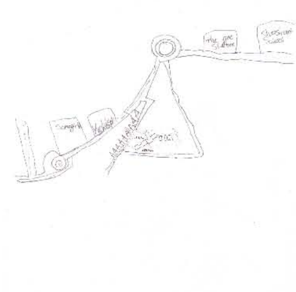
School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP6-031

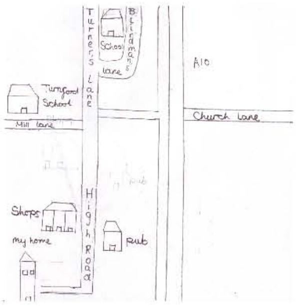
School
Burleigh Primary School

School year
6

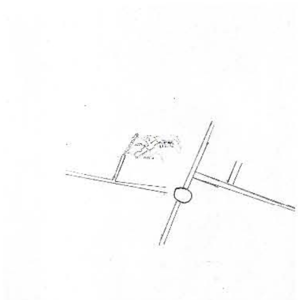
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-036

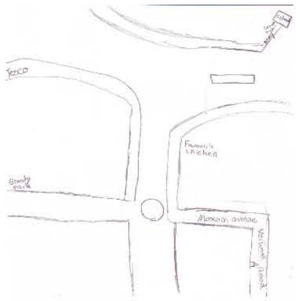
School
Burleigh Primary School

School year
6

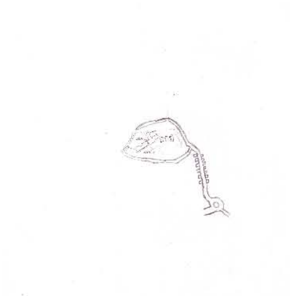
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-038

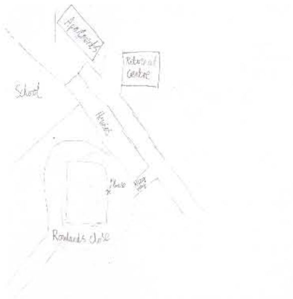
School
Burleigh Primary School

School year
6

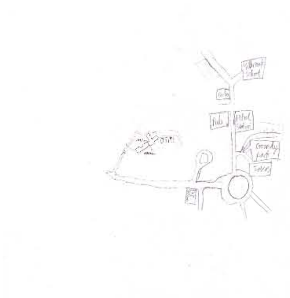
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-044

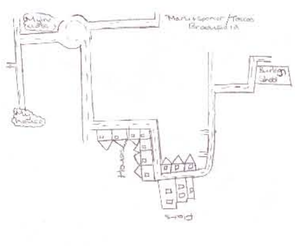
School
Burleigh Primary School

School year
6

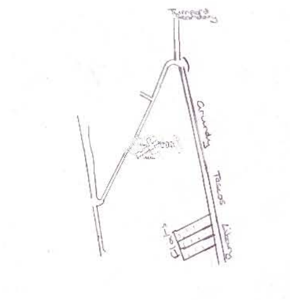
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-026

School
Burleigh Primary School

School year
6

Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map

Reference Number
BP6-033

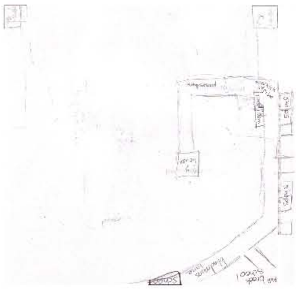
School
Burleigh Primary School

School year
6

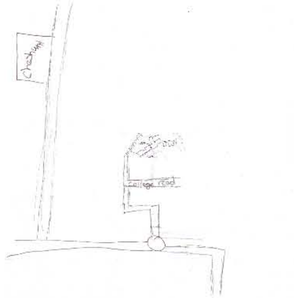
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-024

School
Burleigh Primary School

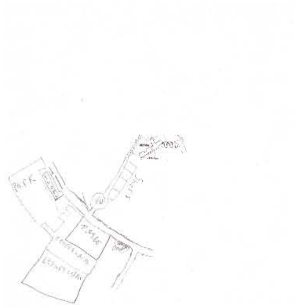
School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP6-027

School
Burleigh Primary School

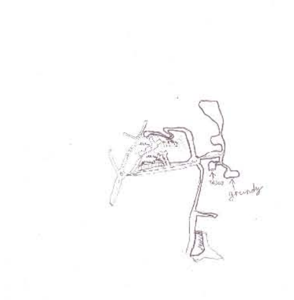
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
BP6-028

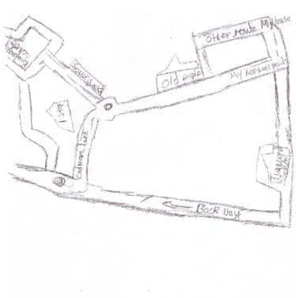
School
Burleigh Primary School

School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
BP6-029

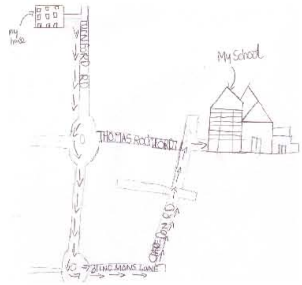
School
Burleigh Primary School

School year
6

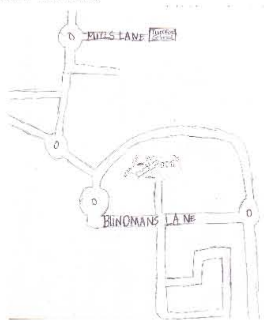
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
BP6-041

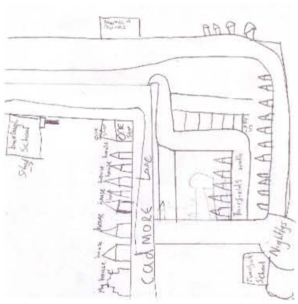
School
Burleigh Primary School

School year
6

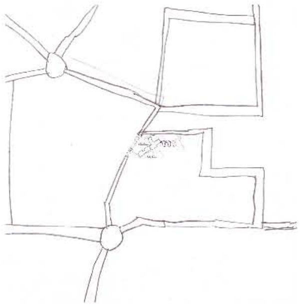
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-005

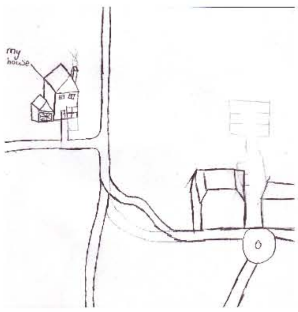
School
Flamstead End Primary Sc...

School year
4

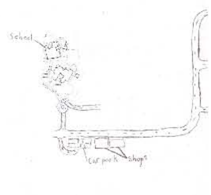
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE4-027

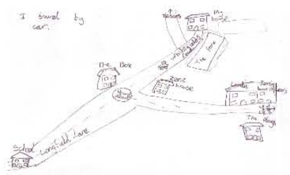
School
Flamstead End Primary Sc...

School year
4

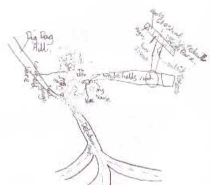
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-008

School

Flamstead End Primary Sc...

School year

4

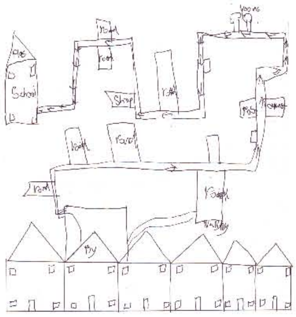
Route - Cartographic Competence

Plan–Pictorial

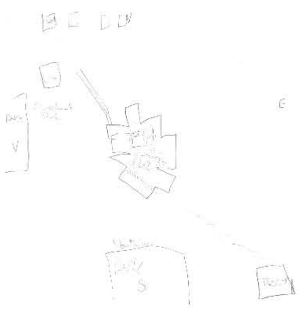
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-043

School

Flamstead End Primary Sc...

School year

4

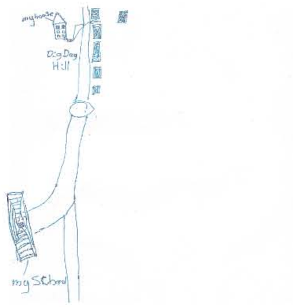
Route - Cartographic Competence

Plan–Pictorial

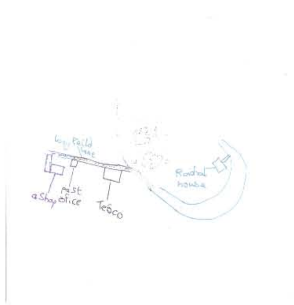
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

FE4-044

School

Flamstead End Primary Sc...

School year

4

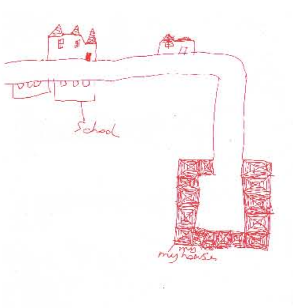
Route - Cartographic Competence

Plan–Pictorial

Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map

Reference Number

FE4-056

School

Flamstead End Primary Sc...

School year

4

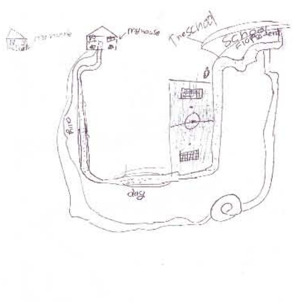
Route - Cartographic Competence

Plan–Pictorial

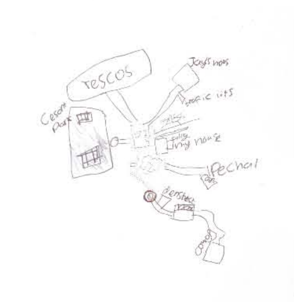
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-059

School

Flamstead End Primary Sc...

School year

5

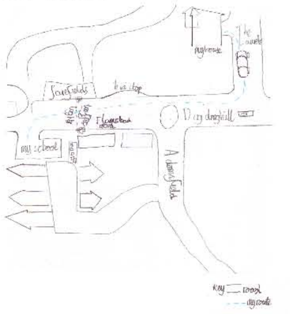
Route - Cartographic Competence

Plan-Pictorial

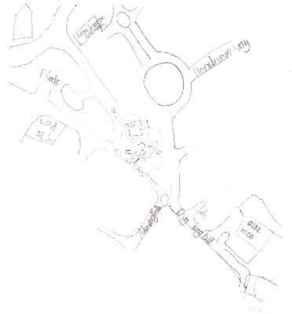
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-042

School

Flamstead End Primary Sc...

School year

5

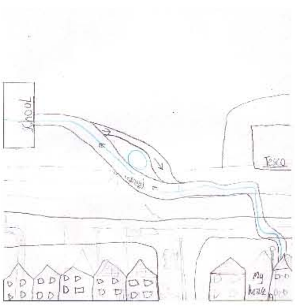
Route - Cartographic Competence

Pictorial

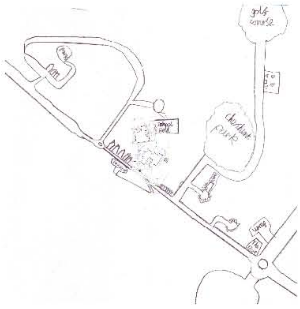
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number

FE5-008

School

Flamstead End Primary Sc...

School year

5

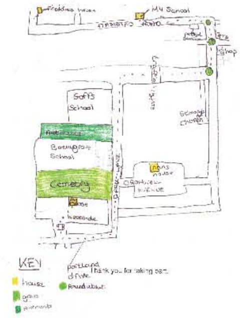
Route - Cartographic Competence

Plan

Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map

Reference Number

FE5-004

School

Flamstead End Primary Sc...

School year

5

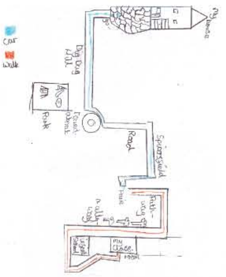
Route - Cartographic Competence

Plan-Pictorial

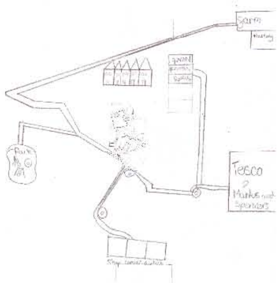
Area - Cartographic Competence

Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-057

School
Flamstead End Primary Sc...

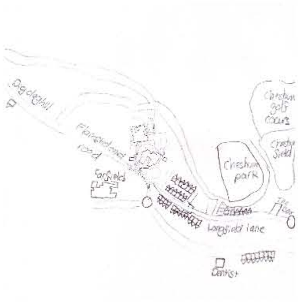
School year
5

Route - Cartographic Competence

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE5-040

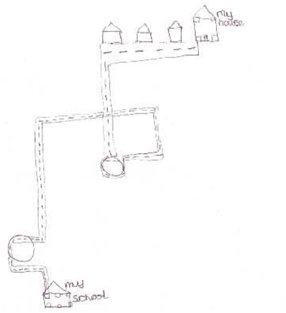
School
Flamstead End Primary Sc...

School year
5

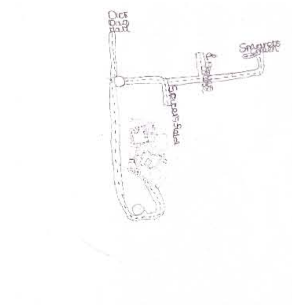
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-025

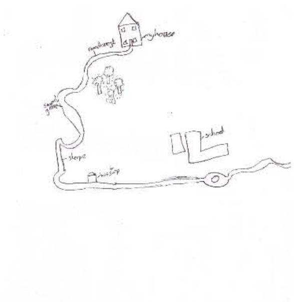
School
Flamstead End Primary Sc...

School year
5

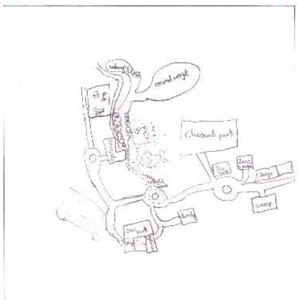
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-012

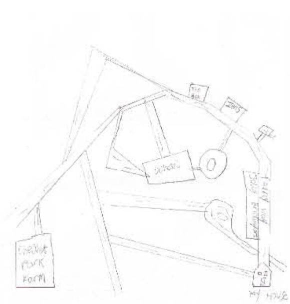
School
Flamstead End Primary Sc...

School year
5

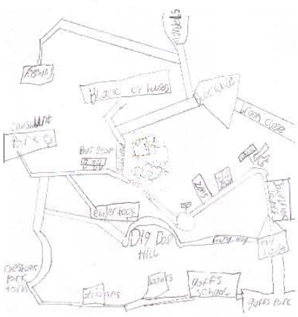
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-036

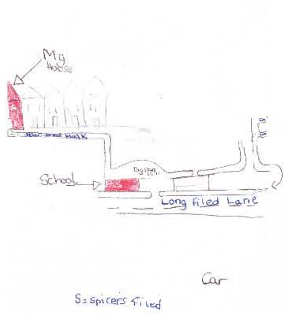
School
Flamstead End Primary Sc...

School year
5

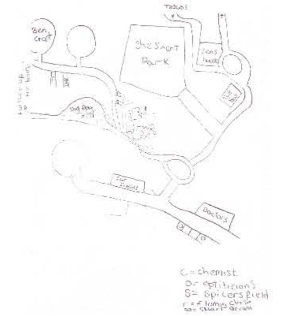
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-031

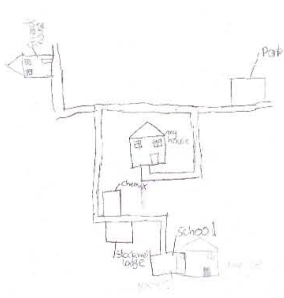
School
Flamstead End Primary Sc...

School year
5

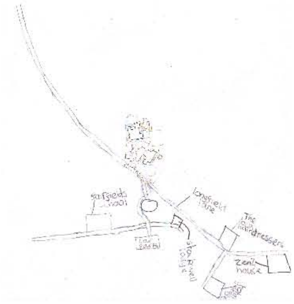
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-035

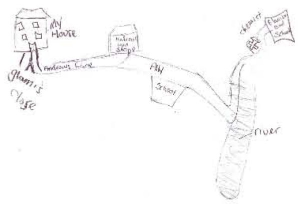
School
Flamstead End Primary Sc...

School year
5

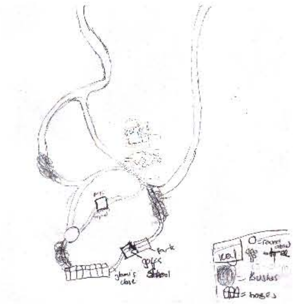
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-005

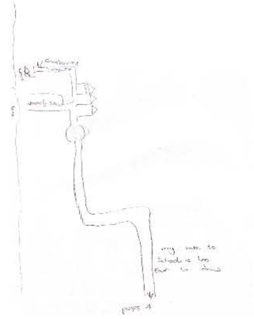
School
Flamstead End Primary Sc...

School year
5

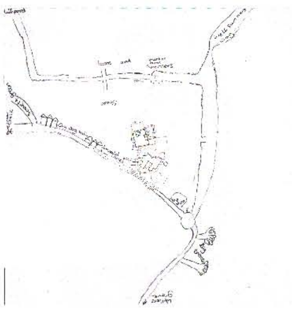
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

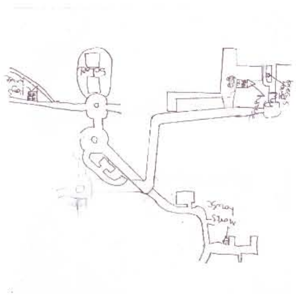


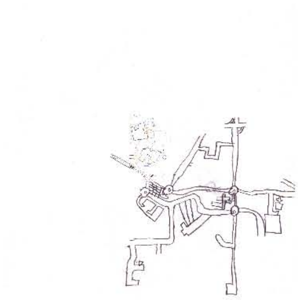
Reference Number
FE5-003
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Pictorial
Area - Cartographic Competence
Plan

Route - Sketch Map


Area - Sketch Map

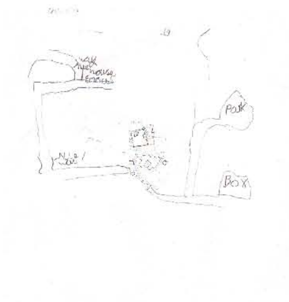

Reference Number
FE5-013
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan
Area - Cartographic Competence
Plan

Route - Sketch Map


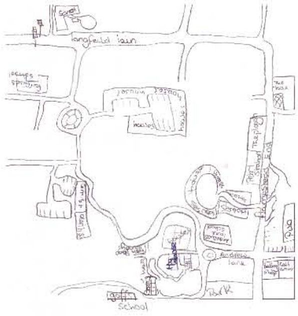
Area - Sketch Map


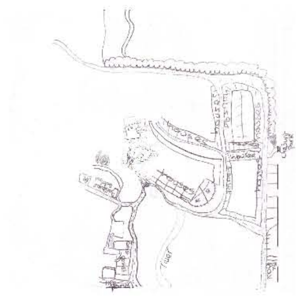
Reference Number
FE5-034
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan-Pictorial
Area - Cartographic Competence
Plan

Route - Sketch Map


Area - Sketch Map


Reference Number
FE5-022
School
Flamstead End Primary Sc...
School year
5
Route - Cartographic Competence
Plan
Area - Cartographic Competence
Plan

Route - Sketch Map


Area - Sketch Map


Reference Number
FE5-026

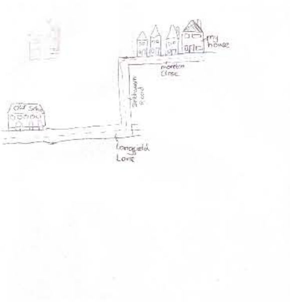
School
Flamstead End Primary Sc...

School year
5

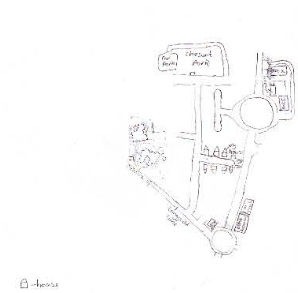
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE5-007

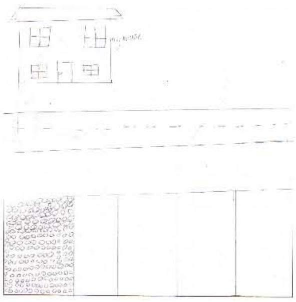
School
Flamstead End Primary Sc...

School year
5

Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
FE6-041

School
Flamstead End Primary Sc...

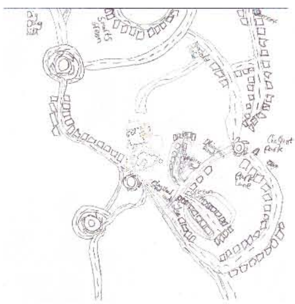
School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-038

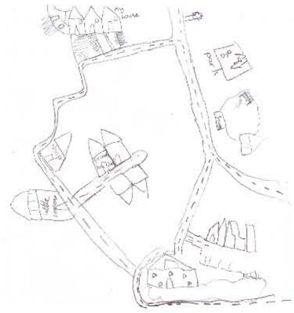
School
Flamstead End Primary Sc...

School year
6

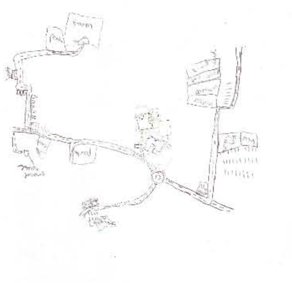
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-042

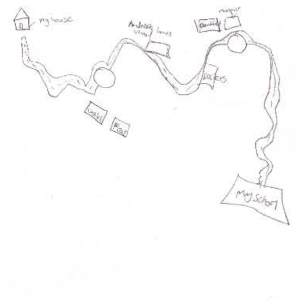
School
Flamstead End Primary Sc...

School year
6

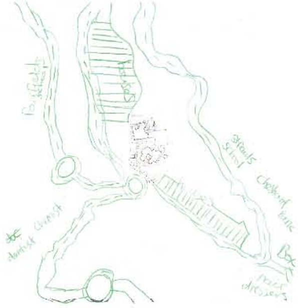
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-044

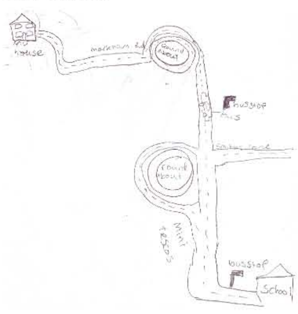
School
Flamstead End Primary Sc...

School year
6

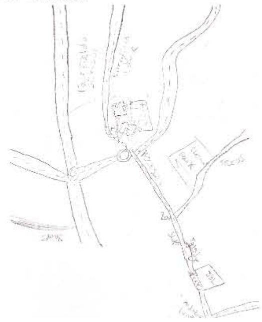
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
No Ref

School
Flamstead End Primary Sc...

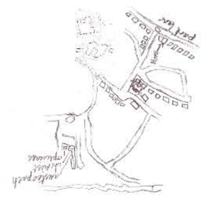
School year
6

Route - Cartographic Competence
No Map

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-002

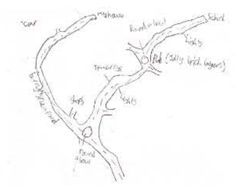
School
Flamstead End Primary Sc...

School year
6

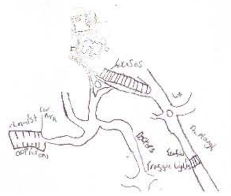
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
No Ref

School
Flamstead End Primary Sc...

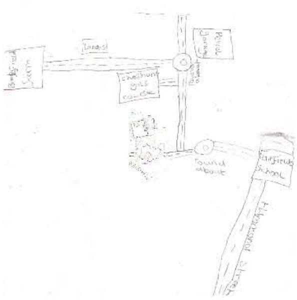
School year
6

Route - Cartographic Competence
No Map

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
No Ref

School
Flamstead End Primary Sc...

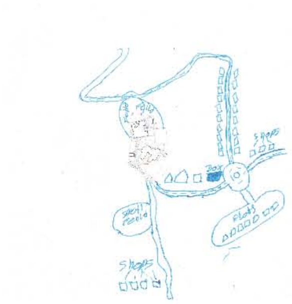
School year
6

Route - Cartographic Competence
No Map

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-039

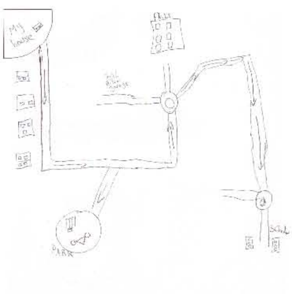
School
Flamstead End Primary Sc...

School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map

Reference Number
No Ref

School
Flamstead End Primary Sc...

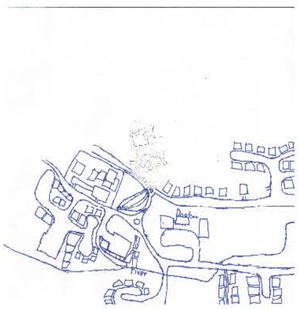
School year
6

Route - Cartographic Competence
No Map

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-047

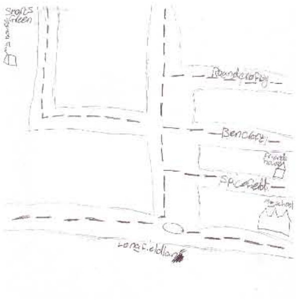
School
Flamstead End Primary Sc...

School year
6

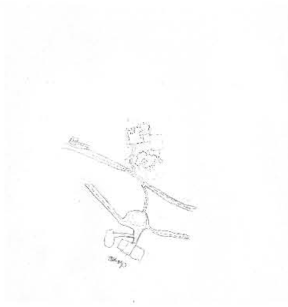
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-046

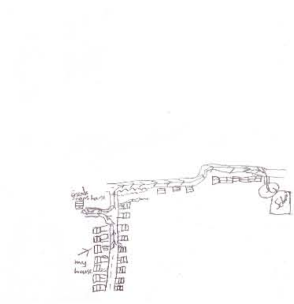
School
Flamstead End Primary Sc...

School year
6

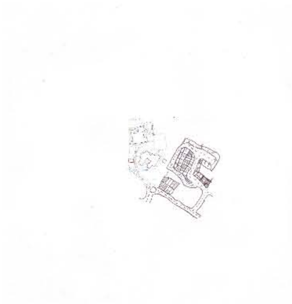
Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-009

School
Flamstead End Primary Sc...

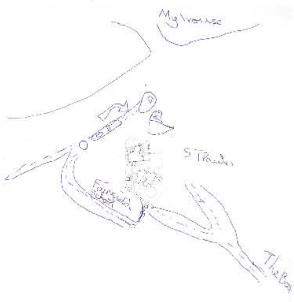
School year
6

Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-008

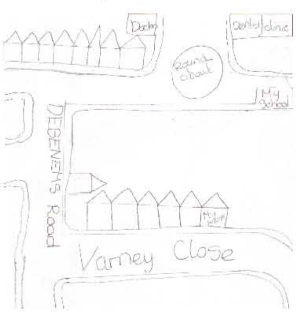
School
Flamstead End Primary Sc...

School year
6

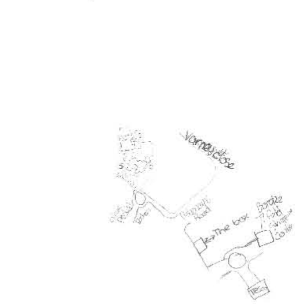
Route - Cartographic Competence
Plan-Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-026

School
Flamstead End Primary Sc...

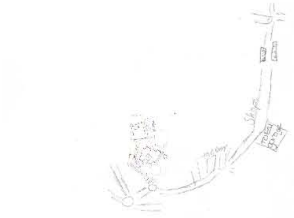
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-004

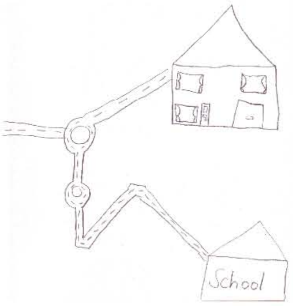
School
Flamstead End Primary Sc...

School year
6

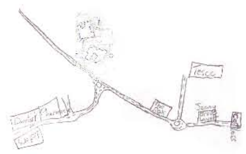
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-023

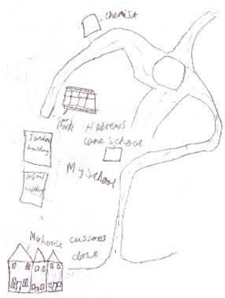
School
Flamstead End Primary Sc...

School year
6

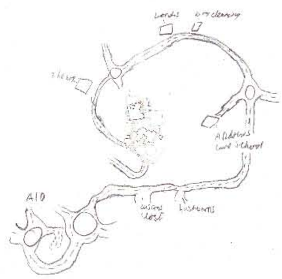
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-054

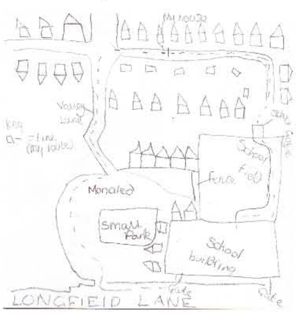
School
Flamstead End Primary Sc...

School year
6

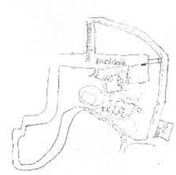
Route - Cartographic Competence
Plan–Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map



Area - Sketch Map



Reference Number
FE6-014

School
Flamstead End Primary Sc...

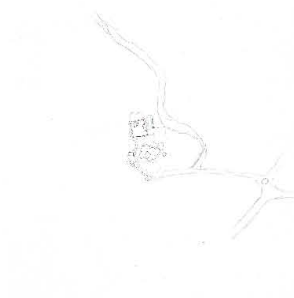
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-007

School
Flamstead End Primary Sc...

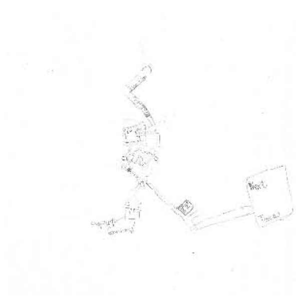
School year
6

Route - Cartographic Competence
Plan

Area - Cartographic Competence
Plan

Route - Sketch Map

Area - Sketch Map



Reference Number
FE6-025

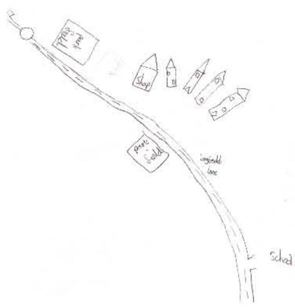
School
Flamstead End Primary Sc...

School year
6

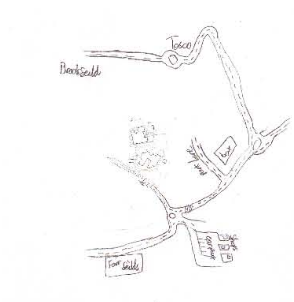
Route - Cartographic Competence
Pictorial

Area - Cartographic Competence
Plan

Route - Sketch Map

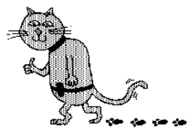


Area - Sketch Map



Appendix 10: Children's questionnaire

CAPABLE Pupil Questionnaire



Name:.. School: Burleigh Primary

Date:.................... School year:............. Reference No.:..................

About you

1. Are you a boy ❑1 or a girl ❑2?

2. What is your date of birth

3. What is the name of the street you live on?

4. If you know your postcode, please write it below

5. (**a**) Do you live in a:

House	❑
Flat in a house	❑
Flat in a block	❑

(**b**)Do you have access to a:

Garden	❑
Communal area	❑
Nearby park	❑

6. About how old were you when you moved to this address?

7. Where are your parents from?

- Mum:
- Dad:

8. How many adults live in your home?

One ❑1 Two ❑2 More than two ❑3

9. How many brothers do you have?
How old are your brothers?............................

10. How many sisters do you have?
How old are your sisters?...........................

11. Which of the following relatives live locally (within 20 minutes from your home)?

Grandparent(s) (Mum's side)	❑	Grandparent(s) (Dad's side)	❑
Aunt or Uncle (Mum's side)	❑	Aunt or Uncle (Dad's side)	❑

12. How many cars are there at home?

None ❑0 One ❑1 Two ❑2 More than two ❑3

13. Do you own or use any of the following?

	Own	Use
Scooter	❑	❑
Skateboard	❑	❑
Roller blades/skates	❑	❑

About your usual journey to school

14. How long does it usually take you to get to school?

Less than 5 mins	❑1	5-10 mins	❑2
10-15 mins	❑3	15-30 mins	❑4
30mins – 1 hour	❑5	Over an hour	❑6

15. How do you usually travel home to school?

Walk	❑1	Car	❑2	Cycle	❑3
School bus	❑4	Public bus	❑5	Train	❑8
Other (please say)7					

16. Whom do you travel to school with?

No one; I travel on my own	❑1
Friends	❑2
Brother or sister	❑3
Parent or other adult	❑4

About your usual journey from school

17. How long does it usually take to get home from school?

Less than 5 mins	❑1	5-10 mins	❑2
10-15 mins	❑3	15-30 mins	❑4
30mins – 1 hour	❑5	Over an hour	❑6

18. How do you usually travel home from school?

Walk	❑1	Car	❑2	Cycle	❑3
School bus	❑4	Public bus	❑5	Train	❑8
Other (please say)7					

19. Whom do you travel from school with?

No one; I travel on my own	❑1
Friends	❑2
Brother or sister	❑3
Parent or other adult	❑4

About your other journeys

20. Are you allowed out on your own?

Yes	❑1
No, but am with friends	❑2
No, but am with older sibling	❑3
No, only with an adult	❑4

Car journeys

21. How often do you make a trip by car (excluding school journeys)?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

Bus journeys

22. How often do you make a trip by bus (excluding school journeys)?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

23. How old were you when you were first allowed to travel on buses without an adult?

Age or I'm not allowed ❑

Cycling

24. Can you ride a bicycle? Yes ❑1 No ❑0

25. Do you own a bicycle? Yes ❑1 No ❑0

26. How often do make a trip by bicycle (excluding school journeys)?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

27. Are you allowed to cycle on main roads without an adult? Yes ❑1 No ❑0

- If **yes**, how old were you when you were first allowed to cycle on main roads? ☐

Walking

28. How often do you walk somewhere (apart from going to school)?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

29. Are you allowed to go for a walk on your own?

Yes	❑1
No but am with friends	❑2
No but am with older sibling	❑3
No only with an adult	❑4

30. From what age were you allowed to cross main roads without an adult?

Age ☐ or I'm not allowed ❑

Going to organised activities

Do not include activities at school.

31. During a normal week how often do you go to organised activities?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

32. What is the total amount of time you spend on organised activities from Monday to Friday?

No time ❑0	Less than half an hour ❑1
½ hour to an hour ❑2	More than one hour ❑3

33. What is the total amount of time you spend on organised activities at the weekend?

No time ❑0	Less than half an hour ❑1
½ hour to an hour ❑2	More than one hour ❑3

34. How do you usually travel to organised activities?

Walk ❑1	Car ❑2	Cycle ❑3
Bus ❑4	Taxi ❑6	Train ❑8
Other (please say)………………………………		

35. Whom do you travel with when you go to organised activities?

No one; I travel on my own.	❑
Friends	❑
Brother or sister	❑
Parent or other adult	❑

Visiting your friends

36. How many friends' houses do you visit? ☐

37. How do you usually travel when you go to visit your friends' houses?

Walk ❑1	Car ❑2	Cycle ❑3
Bus ❑4	Train ❑8	
Other (please say)7		

38. When you go to visit your friends do you usually go on your own?

Yes	❑1
No, with friends	❑2
No, with older sibling	❑3
No, only with an adult	❑4

39. How old were you when you were first allowed to go to friend's houses without an adult?

Age ☐ or I'm not allowed ❑

How you spend your time

40. During a normal week if the weather is good how often do you:

a. Stay at home when you get back from school?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

b. Go to a friend's house?

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

c. Go somewhere else which is outdoors (e.g street park, woods etc)

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

d. Go somewhere indoors (e.g leisure or shopping centre, swimming pool etc)

Never or hardly ever ❑0		Monthly ❑1
Weekly ❑2	2 or 3 days a week ❑3	Most days ❑4

41. How much time do you spend out of the house at the weekend?

0-3 hours ❑0	3-6 hours ❑1
6-9 hours ❑2	9 hours or more ❑3

42. How much time do you spend out of the house after school during the week?

0-3 hours ❑0	3-6 hours ❑1
6-9 hours ❑2	9 hours or more ❑3

43. Do you visit any of the following places alone, only with friends or with an adult?

	Alone	With friends	With adult
Local shops	❑	❑	❑
Shopping centres	❑	❑	❑
Cinema	❑	❑	❑
Sports facilities	❑	❑	❑
Park	❑	❑	❑

44. What is the total amount of time you spend during a week watching TV (including videos and DVDs), using a computer or playing on a games console?

Under 1 hour ❑1	1-4 hours ❑2	4-8 hours ❑3
8-12 hours ❑4	12-16 hours ❑5	Over 16 hours ❑6

Thank you for completing this questionnaire

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